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SPECIAL FEATURES

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ANNUAL BANQUET GRAND BALL ROOM, BELLEVUE STRATFORD, THURSDAY EVENING, SEPT. 18.

President White: Men, it is with a great deal of pleasure this evening that all of us can be here in this room and join in our Second Annual Banquet. We know of no more fitting place for our convention at this particular period in our history than Philadelphia. It goes without saying that this is known as the "City of Brotherly Love." We know that in the early days it was in this city that the beginnings of our great country started. It is true that our Continental Congress met in other places than Philadelphia, preceding the Declaration of Independence, but at the same time that big move which made this nation and had its start began here, and in the same respect we feel that at this particular period in our history, when we are joining here as amalgamated societies under the name of the American Society for Steel Treating, we feel that it is fitting that we be here at this time.

Before going further it has been suggested that we ask the National Officers to stand, one at a time, so that you may all see them, and know that they are human. The first person we will ask to stand will be our First Vice President, Mr. T. E. Barker, of Chicago; Mr. T. D. Lynch, our Second Vice President, from Pittsburgh; Mr. William H. Eisenman, our National Secretary, a man without a home; Mr. William S. Bidle, our Treasurer, from Cleveland; Mr. Howard J. Stagg, our director, from Syracuse; Mr. Emil J. Janitzky, of Chicago; Mr. Walter C. Peterson, of Detroit; Mr. Frank P. Fahy, who has been appointed Director after we received, with regret, the resignation from the Board of Directors of Mr. MacFarland—Mr. Fahy, of New York.

All remain standing, amid applause from members.

I assure you, men, it is with great pleasure that I am able at this time to turn the meeting over to our worthy toastmaster, Mr. Joseph A. Steinmetz, who is president of the Aero Club of Pennsylvania, past president of the Engineers' Club, and in addition member of several technical and engineering societies. Major Steinmetz' forebears came over with William Penn on the good ship Welcome, so that it seems fitting that he should speak for the Philadelphia groups in extending welcome to the Steel Treaters of America. (Applause.)

Mr. Steinmetz: Mr. President, directors and guests, and members of your great society—coming down this evening from the house I met a friend and he asked me where I was going. I said, "Into town." He said, "Well, what are you going to do?" He isn't really inquisitive, but he asked me those questions tonight. I said, "I am going down to see the Steel Treaters." "Oh," he said, "I would like to go along." He thought it means something else, because he has nothing to do with the steel business. (Laughter.)

That brought very largely to mind something that I heard yesterday, and I had a good laugh over it. One fellow met another and said, "Well, old top, how is the world treating you?" Then in a sad and mournful voice he answered, "Very, very seldom."

Irrespective of the terrible shadow that the cloud has cast on the land, I think it is right, and I tell you it is a great pleasure and privilege to speak for our Philadelphia group and for the steel workers and for the steel treaters in that group with whom I have cast my lot, not by accident, but by deliberate intent, and that was some time ago—I had no idea, no dream

of what it meant, because today that is really only the great beginning of America in the steel arts. Your society is to be congratulated on the splendid exhibit you had this week. There were many exceedingly interesting and new things there in the alloys and above all in the stimulation and encouragement and gratification in what I see as the Sheffieldizing of America. There were finished things there that were new, and only the promise and only the finger index pointing to the tremendous tonnage of splendidly finished things that are to come, things well done, well handled, things well forged, and well fabricated and splendidly treated; things that will be unequaled in the arts and marts of the world. Welcome, then, to our city. Welcome from the groups that we know and from those that are not here, because on an occasion like this every Philadelphian stands firm together and welcomes the visitor within our gates. We wish that there were many things more that we could give to you, and many more courtesies we could extend to you. Our industries you know; we are a city of quality. I think by comparison to the finished tonnage—not, perhaps, to the basic or fundamental tonnage of the pig iron or the billet or the ore, but in the net finished result of the things that are well done and well worked out into finished and treated steels, Philadelphia stands without challenge. We make from the smallest needle to the heaviest and most ponderous locomotive. We are about to build one of the big bridges of the world across our Delaware, linking our sister state of New Jersey with Pennsylvania, giving quick access to our playground, the beaches of the Atlantic Coast, so that our men from the West and the far away may ride in unbroken journey to the bathing beaches. That great bridge of steel in the conferences only recently with the engineers that speak in terms that stagger me—they spoke boldly of steel treatments, of new alloys, and of new utensils that indicated a bridge of grace, and a bridge of fine, exquisite lines, and a bridge of extraordinary high tensile strength and a bridge of long, long life. We feel in Philadelphia that we are the iron gate of our state, leading open and outwards unbroken and untrammeled to the seven seas of the world. Our water course of the great Delaware leads away to all of the marts of trade and to all of the open ports where the finished product and the tonnage projects and products of our Western States and of our Central States go out through our gate. We are the iron gate of the finished industries. We are the iron gate of the steel fabricators and the steel makers.

There is one other thought before we introduce our speakers, and that is the tears and the horror and the unhappy, never-to-be-paid-for memories of the idle years when we sat unhappy and heart broken like nincompoops, told to be neutral in thought, deed and action. Those two terrible years are gone, but in the gaunt, terrible years that followed those three years of war and those four years when the millions of men were going down and the billions of treasure were being spent, we did what we could, and in that interval urged by the dire need and impelled by the gaunt spectre of war I think that in those four years more was done to awaken us, show us the leadership and show us the star of our future and of our hope, in our alloys, in our finished steels, metallurgies, fabrications, and output in the factory work than in any four lifetimes that had ever gone before.

Then we come quickly to the picture of those men that did it, those men who stand heroically before the nations of the world, as the men who did the great things, quietly, unobtrusively, many times sad heartedly, who worked in the alloys, who worked in the laboratories heroically through

night and through day, and who helped just as much as the fighting man, and to a degree I will not measure, and furnished him with the implements and tools of war. So it gives us an opportunity to introduce Dr. Albert Sauveur, the Professor of Metallurgy of Harvard University, whose subject is "Steel Wizards, Past and Present." (Applause.)

Dr. Sauveur's Address

Steel Wizards, Past and Present

Dr. Sauveur: Mr. Toastmaster, Members of the American Society for Steel Treating, Ladies and Gentlemen—Your president and toastmaster have shown good judgment, discretion and discrimination in selecting me as the first speaker and in keeping for the end the best they have to offer. It is fitting that we should begin with the lesser light, and finish by the brilliant flash lights that are to follow me.

I am also very glad to be the first speaker, because it relieves me from the necessity of trying to entertain you, feeling certain that the distinguished speakers that are to follow me will entertain you. It makes it easier for me to venture into a talk, which is not humorous, which some of you even might think depressing, feeling certain that the speakers who are to follow me will restore your cheerfulness.

When I had the honor to receive this invitation to speak, I was suggested because of my white hair that should be reminiscences. Now I dislike reminiscences; they are boring, and they give you the feeling that you belong to another generation; that you are a fossil, ready for the shelf. Instead I suggested as a title, rashly, perhaps, "Steel Wizards, Past and Present." Under the cloak of that title I am going to make an appeal for more important contribution on the part of American metallurgists and scientists to the art of making steel. We are rightly proud of our achievements, of our wonderful steel industry, of our country, of our leading position as the greatest iron and steel producing nation in the world, but, lest we forget what we owe to the steel wizards of other lands, it will be salutary to recall their deeds. It will keep us from too complacent an attitude towards other metallurgical nations reporting smaller tonnage production. It should stimulate in us a desire to contribute more substantially to the progress of the art in which we are interested.

We have been eminently successful. Our iron and steel industry has added vastly to the wealth of the nation. A book has been written entitled "The Romance of Steel," or "The Making of a Thousand Millionaires." Our business men, our captains of industry, our financial wizards have played their parts most successfully. Can the same tribute be paid to our scientific and technical wizards? Have they played their parts or have they been satisfied with following the tracks of wizards of other nations? Can they be accused of parasitic tendencies?

I should first describe what I have in mind by "steel wizards." I mean those men who have contributed the great basic invention upon which the iron and steel industry is founded. Men like Huntsmann, Cort, Reaumur, Bessemer, Abraham Darby, Tschernoff, Osmond, LeChatelier, Sorby, Howe; men whose discoveries, inventions or scientific contributions are epoch making.

Is it not true that, although being by far the greatest iron and steel producing country, we have not contributed our share of these great inventions, discoveries and scientific achievements? Is it not true that our

contributions have been chiefly of a mechanical kind, that they have consisted in the main in labor saving devices and machinery destined to cheapen and speed up productions. In this we have been undoubtedly successful and the importance of speeding up and cheapening production is not to be denied or belittled, but should we be satisfied with great advances in this direction only?

American mechanical wizards have passed through our steel plants, and have left their marks, but do we not look in vain for evidences of the passage of American metallurgical wizards?

Is it not true, and is not the thought somewhat humiliating, that if all the contributions of American metallurgists and scientists to the art of making steel had never been made, iron and steel would continue to be manufactured, worked and treated practically as they are today, in reduced proportions to be sure, but of unimpaired quality?

Is it not also true that if the contributions of English metallurgists and scientists were withdrawn, the entire structure of the iron and steel industry would ignominiously collapse? We would have neither puddling furnaces, nor crucible steel, nor Bessemer steel, nor open hearth steel, nor rolling or forging appliances..

We make more pig iron than any other country, but the blast furnace was neither invented nor developed in the United States. W have discarded the expensive fuel, charcoal, but this was first done by the Englishman, Dud Dudley, in 1619. We make more coke and use more coke for iron making than any other nation, but coke was first made and first used as a blast furnace fuel in England by Abraham Darby, who in 1735 had the inspiration of treating coal as the charcoal burners were treating wood, and this invaluable metallurgical fuel was his gift to the world.

More waste gases issue from our blast furnaces than in any other country and possibly we utilize it more thoroughly, but this has been made possible by the invention of metallurgists of other nations, by Aubertat in France, who in 1811 took a patent for the utilization of the waste gases. By James Beaumont Neilson, of Glasgow, who in 1828 first suggested the use of hot blast, by Faber du Four in France and James Palmer Budd in England, who in 1833 and 1845, respectively, suggested the heating of the blast by the burning of the waste gases; by Philip Taylor in England, who in 1840 suggested the closing of the top of the furnace that the waste gases might be collected, and G. Parry, of England, who in 1850 invented the bell and hopper or cup and cone as a means of closing the top of the furnace. By the Englishman, E. A. Cowper, who in 1860 introduced the use of regenerative brick stoves.

We have now, I believe, a greater number of gas blowing engines than any country, but the internal combustion engine using blast furnace gas was developed at Seraing in Belgium and we were at first quite reluctant to adopt it.

As notable improvements in blast furnace operations, we may claim, I believe, the automatic loading by skip cars and inclined planes and the double bell and hopper which that method requires.

We make more wrought iron than any other country, but the Reverberatory Puddling Furnace was invented in England in 1784 by Henry Cort and the Wet Puddling process introduced in that country also by James Hall and S. B. Rogers in about 1830.

We have a very important crucible steel industry, but crucible steel

was first made by an English clock maker, Huntsman, in 1740, while the method we follow by which we do away with the necessity of using blister or converted steel was introduced by the Englishman, Mushet, in 1801.

We are making more Bessemer steel than any other nation, but the Bessemer converter and its necessary equipment was invented in 1856 by the illustrious Bessemer, an Englishman of French parentage, and the Bessemer process made successful by Robert Forrester Musht, another Englishman, who discovered the necessity of adding Spiegeleisen or Manganese in some other form.

The basic Bessemer process in which, to be true, we are little interested, resulted from the masterly investigation and study of two Englishmen, Sidney Gilchrist Thomas and his cousin, Percy C. Gilchrist, in 1878.

We make more open hearth steel than any other country, but the regenerative furnace is not an American invention and open hearth steel was first made by the French metallurgist, Emile Martin, in 1865.

We are, if I am not mistaken, making more electric steel than any other country, but we took practically no part in the development of the electric furnace for steel making, the furnace we must use being the invention of the French metallurgist, Heroult.

We make more ferro alloys and more special or alloy steels than any other nation, but the most important of these, with the exception of high speed steel, we owe to the labor of metallurgists and scientists of other countries.

Our yearly tonnage of malleable castings is very much greater than that of any other nation, but the invention of the process is to be credited to the illustrious French chemist, Reaumur, who described it in 1722. To him also we owe the first scientific study and disclosure of the cementation and case hardening processes.

We roll and forge more steel than any other nation, but with the important exception of the three high rolling mill, rolling and forging appliances were not invented by us. The two high pull over grooved mill was invented by Cort; the reversing mill in 1866 by Ramsbatten in England; the universal mill is a German invention; the continuous mill was invented in 1861 by the Englishman, Charles White, although it has been much improved by the American engineers, Bedson and Morgan.

We owe the steam hammer to the genius of two Englishmen, James Watts and James Nasmyth, and the hydraulic presses to the Englishmen, Bessemer and Gledhill.

We heat treat a larger tonnage of steel than any other country, but can we claim that the scientific investigations which have lifted the art of treating steel to such high degree of perfection is due chiefly to American metallurgists and scientists? Is it not true that with the exception of the invaluable contributions of Professor Howe the work has been done chiefly in Russia by Tschernoff, in England by Sorby, Roberts, Austen, Arnold, Stead and Rosenhain, and in France by Osmond, LaChatelier, Guillet, Charpy, Portevin, Chevesnard and Grenet?

The discovery of high speed steel, or, if you prefer, of the treatment importing high speed properties to certain steels, by Taylor and Maunsel White, I am inclined to consider as our one epoch making contribution to the metallurgy of steel.

I am well aware that some have tried to throw doubts on the novelty of this discovery, but in my opinion their contentions are not only un-

generous, but unjustified. It continues to shine as the brightest American star of the metallurgical sky.

On the roll of honor for notable inventions, discoveries, or improvements in the art of making, working or heating iron and steel, or for notable and fruitful scientific contributions to that art, the following Americans are, I believe, entitled to a place:

Campbell, for designing the first tilting open hearth furnace.

John Fritz, for his invention of the three-high rolling mill.

James Gayley, for conceiving and executing the drying of the air blown in blast furnaces.

A. L. Holley, for notable improvements in the construction of Bessemer mills.

Henry Marion Howe, for his invaluable scientific contributions to our knowledge of steel.

W. R. Jones, for introducing the use of mixers in steel making.

Julian Kennedy, for notable improvements in the construction of blast furnaces and of blast furnace equipments.

F. W. Taylor and Maunsel White, for their epoch making discovery of high speed steel.

Samuel Thomas Wellman, for notable improvements in the construction of open hearth furnaces, for designing and construction charging machines and other useful appliances.

Frederick W. Wood, for his introduction of the car casting method for steel ingots.

The natural conclusion of my remarks must be a wish that we may become more prolific in steel wizards of the first order; that is, metallurgists who will not be satisfied in merely speeding up production through ingenius labor saving and other devices, but who will bend their energy and talent towards the discovery of new and epoch making methods of producing, working and treating steel that we may in future, as the leading metallurgical country, contribute our full share to metallurgical progress. Let me express the further wish that some of these steel wizards may be members of the American Society for Steel Treating; indeed, that some of them may be present in this hall tonight.

Now I don't like to leave you with these sobering thoughts in your mind. I know that the speakers that are following me will dispel those thoughts. At the same time I should like to help a little, and I don't like you to think because I am not entertaining you with stories that I cannot tell a story. But it is sometimes difficult to introduce a story in a graceful and fitting manner so as to connect it in a reasonable way with your talk. That was my topic. Fortunately I happened to mention to my distinguished colleague, Professor Richards, that I felt very nervous about talking to so large and imposing an assembly as this, and he said, "Well, don't be afraid; your Heavenly Father will watch you." And of course that gave me the connecting link, because it immediately brought to my mind this story:

Father and mother were traveling with little Johnnie in a sleeping car, and they put little Johnnie to bed and they said, "Johnnie, you must be very good; don't be afraid, your Heavenly Father will take care of you," but in the middle of the night little Johnnie got a little uneasy and he said, "Mother, are you there?" No answer. "Father, are you there?" No answer. And he repeated that question a few times until a grumpy old man in the next section got sort of peeved and he said, "Yes, father is here and

mother is here and Aunt Lucy is here and Cousin Lizzy is here, and now you go to sleep." And upon hearing the voice the little boy said to his mother, "Was that the voice of our Heavenly Father?"

Mr. Steinmetz: I think before introducing our next speaker it would be a splendid tribute and one quite worthy for the great Steel Treaters' Society of America to stand for a very brief moment in tribute and well wishes and hopes that that splendid, brave, indomitable and glorious little country of Belgium, the home of our speaker, comes back into industry, into the fullness of her life, into prosperity and happiness and peace forever. (Applause; then members stand for a moment in silent tribute.)

What Dr. Sauveur has said hits us. It hits us right fair and square, and it is good for us. In this room are the wizards of the present and of the past in the steels, and for one I am convinced that in a very short space of time we will be in a great group leadership in the steel working and fabricating and hardening and tempering and finishing arts, and in the steel making and in original discoveries. He harkens back to the time when we were a great rich, ample and virgin country, seemingly inexhaustible in supplies of coal, timber, oil fields, in almost everything. Naturally we wasted like pirates. We were tonnage people—that is all. It meant nothing to sweep away the forests of our nation. It means nothing to wreck in a generation the work of a thousand years. We are doing it yet, but we are learning a little bit. We think of China and her hundreds of thousands of square miles of yellow mud and the torrential rains running down over it; nothing but dirt and filth over that splendid, splendid land which was once a forest area. All that we are doing, and have done it boldly, and foolishly, and we didn't give a damn. We built then like giants, and we are doing that now, but the day is coming when we will have to polish like jewelers. The day is coming when we will have to watch the little economies. It is but natural, too, that we adopted the ideas and the practices of England. Why shouldn't we? He speaks of inventions way back in 1720. Why most of our forefathers were smiting Indians back in the woods in 1720. Of course, when the splendid men of England and France came here, they were the leaders in the arts they knew. Natural enough that they should bring with them the arts and the inventions, and the people came after them, and rightly and properly it was theirs, and we helped them. Perhaps we worked out there on the cinder pile some of those that are back there, and perhaps we had to learn. So our teachers did come from over there, and I hope the day is near when our teachers from here will go over there.

Our next speaker is a man whom I thank publicly and openly for many of the great inspirations of my life. He was my professor at Lehigh, and from him I learned of the metallurgies. He gave me the inspiration in the non-ferrous alloys, and many of the foundation stones are inscribed with the initials of Joseph W. Richards, professor in charge of the Department of Metallurgy, Lehigh University, and Secretary of the American Electro-Chemical Society. He will tell us of "The Ancient and Honorable Craft of Steel Treating." Dr. Richards. (Applause.)

Dr. Richards' Address

Ancient and Honorable Craft of Steel Treating

Dr. Richards: Mr. Toastmaster and Members of the American Society for Steel Treating, Ladies and Gentlemen: It is a great pleasure for me to meet you again, and I am going to take some of your time tonight

in connecting your society with the ancient and honorable art as it has existed for no one knows how long.

First, it is most honorable. There was once a painting here in Philadelphia, in the gallery of Mr. Harrison, within about two blocks of where we are sitting, painted by Schuessele, which showed King Solomon calling together the workers of his temple, intending to put in the seat of honor the most distinguished workman. He called together the workers in stone, in gold and silver, etc., and when they came into his presence one of them walked up to the chair and took it. He was the smith. Solomon said: "By what right do you take that chair?" "Well, he said to the stone mason, "Who made your tools?" "The blacksmith." He said to the worker in wood, "Who made your tools?" "The Blacksmith." And so he went through the whole row of them. When he got through he said to King Solomon, "All of these could do nothing if it hadn't been for me making

their tools." King Solomon recognized the force of the argument and said, "He is the chief craftsman of the builders of the temple." So you are the tool makers, and if anyone will stop to consider what the world would do without steel tools, he will get a faint idea of the usefulness of your profession.

Now, as to its antiquity. You will read in the books and encyclopedias that the age of gold was succeeded by the age of bronze and then the age of iron. I wish to tell you that I think that is wrong, although almost all of the books will tell it to you. The age of iron undoubtedly preceded the age of bronze, and the use of gold existed only where gold was abundant. In those countries where gold and copper occurred native (there are not many such places), they were used, but they were too soft to be of much use in building or in stone making and cutting, and undoubtedly the first metal that was made was iron. There is no doubt at all that the pyramids, with their huge stone slabs and blocks, were cut with iron tools.

You can go back of them thousands of years in the history of Nineveh and Assyria and find there that they must have known the metallurgy of iron. The making of iron is the oldest metallurgical art, and the treating of steel was coincident with it, because the first men who found iron very quickly made steel, and the treatment of steel was in all ages considered as part of the art of the worker in iron.

During the Middle Ages, when combat was almost man to man, a man's life depended on his sword and his armor, and the workers of steel were in the highest places. Their Guilds ruled very much as they pleased in some of those middle European cities, and the art of the smith, which was practically that of working in iron and steel, was considered one of the most honorable there was. I have a few notes here as to some of the restrictions which were placed on your predecessors of the tenth and the twelfth and the sixteenth centuries, and perhaps many of you have not heard them. I think they will interest you.

"Smiths were regarded in general as sorcerers and wise guys who were not afraid of Death and the Devil." That is a quotation from one of the old writers. "A boy, to be brought in as an apprentice to the smith, must be the legitimate son of honorable parents. No child of a night watchman, or a street musician, or a tower or gate watchman, a baker, a miller, a tanner, a linen weaver, a sheep herder, or a tax collector, could be a smith." (Laughter.) "The apprentice lad had to take the oath of secrecy and furnish about fifty to one hundred gulden as a bond to keep his oath." "He was first apprentice and could only become a master smith when he had produced a real masterpiece. Besides this he must pay when he became a master for a splendid dinner to the Guild and take a particular oath not to practice any sorcery, not to leave the country, not to divulge the secrets of the trade to any but his own son, or, having no son, to his nearest blood relation, and at the death of the master smith it was the custom to cremate his body and bury the ashes under the anvil in the smithy."

I will quote a few of the old recipes or saying as to how steel was treated and what it was. Said one old gentleman in 1540—(and I want you to notice what a good idea he had of steel): "Steel is nothing else but iron worked up with much art and much soaking in the fire until it is brought to a perfect mixture and given properties it did not before possess. Likewise, it may have taken up suitable materials of a dry or fatty tendency; also a certain moistness and hereby becomes white and denser. The long firing also opens up and softens its pores, which are drawn together again tightly by the power of the cold of the quenching water. The iron is thus given hardness, and the hardness makes it brittle. As iron can be made from any iron ore, likewise steel can be made from any pure iron."

That is 1540, when they were commencing to get some real ideas on steel. One of the first reliable books on the metallurgy of iron and steel was written by our friend, Swedenborg, the theologian.

Another says, "Steel is nobler than iron, and there are two kinds, the artificial and the natural. The natural is hard and more easily broken than iron." By natural he meant the steel made directly in the furnace from the ore. "The artificial is made of the hardest, purest iron, with limestone. The best shows a small white grain, does not rust, and has no cracks. To harden it properly clean it well and quench it three to four times when red hot in a mixture of three to four parts of radish juice and decoction of earth worms. It will then cut iron like lead." Earth worms seem to be a particular recipe of those old steel treaters.

Another one, named Nostradamus, said, "Distill earth worms with turnips and cucumber roots mixed in equal proportions. The iron is quenched in this distilled liquid. Repeat it if you want it harder."

Another German book said, "Macerate the leaves of laurel with the stems and sprouts, pass the juice through a linen cloth and keep it in a glass vessel; mix the juice with equal proportions of urine from a man and the juice of earthworms; dip the glowing iron in this mixture and keep it immersed until golden specks appear. To make the most desirable edges on swords and daggers, take a handful of soot, four ounces of linseed oil and decoction of earth worms, and boil it together; make the cutting edge red hot and quench in this liquid." (Laughter.)

Here is one gem which I'm going to read you unexpurgated. Theophilus Presbyter, a Benedictine monk, in the Twelfth century, says: "To harden iron this method is in use for tools to work glass and stone; take a three-year-old billy goat, tie him up three days without food; on the fourth day feed him ferns and nothing else; when he has lived on these two days, put him the following night into a vat or tub with holes in the bottom under which you put a sound bowl to collect his urine. After collecting this two or three nights, when you have enough, let the billy goat go, but harden the iron in his urine." (Laughter.) I am afraid you are learning some interesting recipes tonight.

In the Middle Ages, swords were some of the most precious belongings, and the swords of Damascus, Toledo and Japan were particularly valued. I have at home a Japanese sword about 450 years old, and this is the way in which it was made. A piece of iron about six inches long and two inches wide was taken and doubled over on itself, and then welded out until it was the original length. That operation of doubling it and welding it and working it out was repeated fifteen times. At the end of that time three pieces of similar size were thus worked in the same way. Those three pieces placed one on top of the other were then worked out into a bar six inches long, two inches wide, and that bar was again split in two and welded five times. With a skilled workman getting about twenty cents a day, that treatment did not cost much in those days, and you can figure out that there are about four million layers in that steel blade, and really I believe that this tremendous amount of working and those tremendous number of layers account in large measure for the beauty and the strength of those old swords. It is related of Richard Cour De Leon, the English King, that when he was in Palestine he had his big two-handled sword with him and Saladin, the Saracen Emperor, met him. They were bragging about their swords and Richard ordered them to put down an iron bar about an inch in diameter. He whirled his sword around his head and came down and cut that steel bar in two. Some feats of that sort were really done with those magnificent old two-edged swords about five feet long, with an immense handle for two hands. Saladin took out his curved scimitar and called an attendant, who threw a ladies' veil up into the air; Saladin cut it in two with his scimitar as it was floating in the air. Something like that can be done with those magnificent swords of Damascus.

The ancientness of your trade is something in which you take a second place to nobody. Perhaps the worker in wrought iron may claim to be the older of the two arts, but the worker in steel certainly followed him very closely, and in ancient times the two were one trade.

There is a piece of iron which has nickel in it and some carbon, which was found in the Pyramid of Cheops, and dates from about the year 3000 B. C., but that is comparatively modern. I am sure that, although we haven't the dates to give, that the metallurgy of iron and steel dates back thousands of years before that, and you are the present representatives of that ancient art, an art which passed through a great many vicissitudes. Those old workers certainly knew their trade as far as their capacities and the things at their command would allow it, but at the present time you have the great resources of the chemical and physical laboratories and modern methods which have been devised.

The Simplest Form of Pyrometer

I wish to close with a plea to you to use those facilities to the fullest extent. Most of you have seen, perhaps, that picture of the simplest form of pyrometer, the old man who opens a furnace door and looks in. Now it is only the simplest form of a steel treater that will allow his work to depend on that method of getting temperature. With the appliances now at our command it is possible for us to use scientific and exact methods instead of mere "rule of thumb," and to connect our practice with the accumulated experience of former ages.

You are the most ancient of metallurgical workers, and the most honorable. May I not plead with you to become the most scientific. (Applause.)

Mr. Steinmetz: I think Dr. Richards' definition of the ancient smith impresses us. I think to a degree it holds good today—"not afraid of fire or the Devil." I have been in many of the big forges in Pittsburgh and our district here when I want to tell you I was pretty well scared. I think the society undoubtedly will second his objection to the tax collectors, and I move that that holds forever good. They are getting too close to us now anyhow, and we don't want them in the steel business. I can see great improvements in the smaller and better finished articles in the treatments with radish juice and earth worms. That certainly sounds like one of the wartime specifications that we wrestled with. (Applause and laughter.) We all can learn something. We had during the stress and trials and tribulations of that interval here in Philadelphia a very thrilling lecture; it impressed me; I don't think anything has impressed me more than this lecture. It was a very direct hit at all of us. There were probably a thousand men present. The topic was "Are You a Nut or Are You a Rivet?" He worked it out splendidly. At first it rather hurt us, but he went on this theory, that a nut gets loose and it turns willy-nilly, and it wobbles and then lets go. Not so a rivet—well set, sturdy, positive and eternal. It

knows its job and it sticks. There is a whole lot in that. So we have as our next speaker a "Rivet," a man who knows what he is talking about. He is well set. There is no wobble about him. That man is Samuel M. Vauclain, president of the Baldwin Locomotive Works, and Mr. Vauclain will tell us of his impressions abroad. (Applause.)

Mr. Vauclain's Address

Impressions from Abroad

Mr. Vauclain: Mr. Toastmaster, Heat Treaters and Ladies—I am the last speaker. Probably if you are interested I will endeavor to fill in, and when anybody gets too full, if they will simply hold up their hands I will cease. I have been assigned a subject, "My Impressions Abroad."

Now, I had many impressions while I was abroad, perhaps some of them I would not care to mention here, but the principal impressions which I had when abroad no doubt may interest you, because they simply concerned business. Business that I was engaged in, business that you are all engaged in, and business that some of my Philadelphia friends are engaged in, who are not represented among the steel treaters.

In order to get a real impression abroad one must so travel that he can be impressed. Those who go abroad and simply inhabit the luxurious hotels which are to be found everywhere, even in the most devastated countries or so-called devastated countries of Europe, a proper conception of what Europe is today cannot be had. But fortunately, if you can afford to pay for the use of an auto, and endure the hardships which an auto trip through that country, if it is made in anything like American time, will cause you a correct impression, not only of the condition of the country, but a correct impression of the attitude of the people of those countries can be had.

Of course, to be perfectly impressed, one must have no pre-thought on the matter. He must not have arrived at a conclusion before he visits the country. He must be willing to judge the country as he sees it, to judge the people as he sees them, and in that way come back with profit, not only to himself, but to the people whom he represents.

Getting off the steamer in Cherbourg and taking an auto for Paris prepares one for what he is going to see as he travels on through Europe toward Russia.

The magnificent country, which probably was robbed of almost everything it had to support the armies in France, practically is a paradise. The people are contented, they are earnest in their work, they arise with the sun, and they go to bed when no longer they are able to see.

But the universal feeling of contentment which those people have in that section is simply nothing compared with the universal contentment and confidence in each other that is found among the people where war has been waged backwards and forwards for at least four or five years.

Leaving Paris, and Paris was just the same old Paris we knew before the war, very little difference excepting that the people were all more earnest, they were applying themselves to reconstruction, not the reconstruction of the devastated lands, but the reconstruction of their business to conform to the more serious requirements of the times to provide themselves with the wherewith to conduct a business when money was almost impossible to get, and where the rate of exchange had fallen to an unparalleled point. France demonstrated to me that, in a short few days before I left for the Far East, no one need to worry in America as to what would

become of France. France would take care of that herself, and in her own inimitable manner.

Taking an auto and going down through that part of France where war waged, one had greater confidence not only in Europe, but had greater confidence in the people of this world, in the human race, of their ability to survive almost any catastrophe which might happen to them.

Every field that a year before had been shot to pieces, that had been practically ruined, as we were told in this country, had been restored to its original beauty and efficiency.

The most beautiful country that man ever gazed upon, with buildings shattered and destroyed, whole towns removed, but every field and every roadway in perfect order, grain growing where but a year before shot and shell and barbed wire abounded, and not a single sad face, people in black who had lost members of their families near and dear to them, but I reasoned out that these people rejoiced and were glad that it had been no worse, and that there was at least something left them to begin life's work in this world with once more. People who had beautiful farm lands, beautiful vineyards perfectly kept, were perfectly happy to live in the cellar with a stove-pipe shoved up through the first floor, because the rest of the house had gone.

And it would require time, it would require some assistance, it would require some years of labor before another house could be built. But not one single complaint was made to me by anybody with whom I conversed throughout the devastated section of France, which I visited. Everywhere factories were beginning to run, the farms seemed to have been recovered and the factories were fast being put into the same condition.

Having a little business engagement with my bosom friends down in Poland, it became necessary to go to Warsaw. A trip to Warsaw eight months ago was an education because these new states were then endeavoring to get their borders in shape, their accustomed officers well stationed so that no guilty man could escape, that every person who wished to cross would have to be examined inside and out before he was permitted to pass. I made up my mind that the going might not be very good in that section of the country, and therefore I surprised the railroad people by hiring for my trip a whole passenger coach, a sleeping coach, which had some eight or ten staterooms in it, little bits of things, for my party. It was fortunate that I did so, because the occupancy of a car of this description through countries and over railroads where traveling is a real art, where standing room only is to be found, where every available square inch of the platform is occupied by those who are not fortunate enough to get into the cars, or be pulled through the windows and the roofs themselves are occupied, but the people don't mind that. They are glad that they are able to ride on the roof of a car, and they are not finding fault with their friends or their neighbors because they have not a Pullman berth to ride in. They will stand at a railroad station for three weeks, come every day for three weeks waiting for an opportunity for the single train which may move through the city to get on a car for standing room to the next station, and this cheerfully.

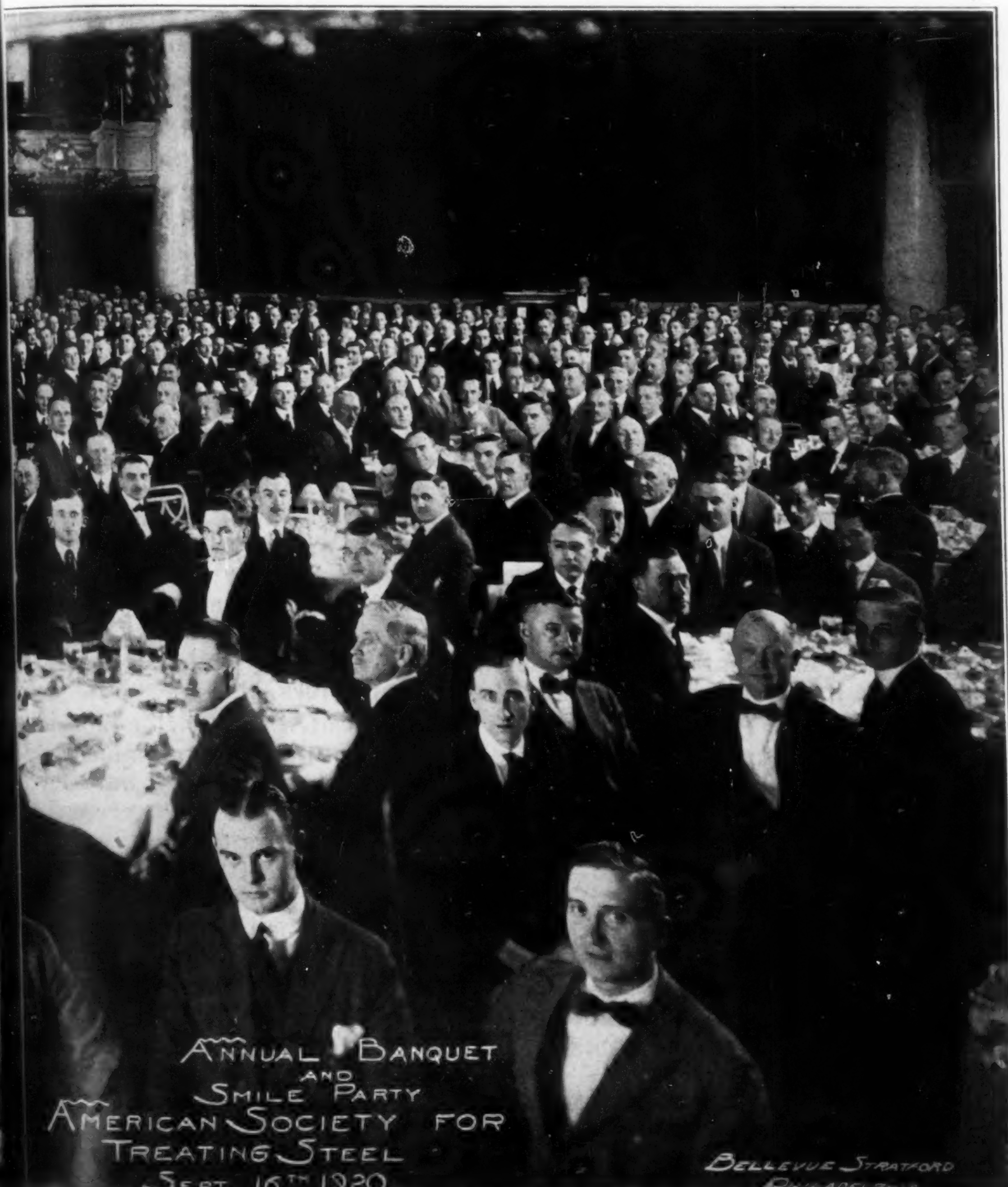
Now the impression made upon me by witnessing this devotion to their labors or their duties or their business or to their pleasures made me feel that if these people can be satisfied and happy and industrious under conditions of this kind, I had better get back to America and endeavor to

put the same thing in practice among those with whom I am associated, and who have the pleasure or difficulty of working for me.

Far off through Poland up to Danzig, which is a free state, the grim army of the British nation in full possession, splendid to look at, stern, with a German population staring them squarely in the face. Danzig is not a Polish country, it is a German state, a German city, and a German state. But under the British it is British, because it is under the British, the British appropriated a church and every man in the British army stationed there goes to church with his musket on his shoulder and his cartridges in his belt. It reminds me of our old time Puritanism in this country. You had to do it, and if you did not do it, if you were not good, you would be made to be good.

I find no difficulty there in getting along; I found the people determined to prosper under the situation. Their town had not been devastated in any manner, and therefore left it and left it with great pleasure, because I felt that I would get no further ideas there, that I had better penetrate farther on.

Arriving back in Warsaw I determined to go down through Galicia via Krakow, Lembourg, over to Chernovitz, and then down through Rumania to Bucharest. And unless you Americans who desire to find out the conditions in Europe make this trip you will never realize what the true conditions in those Balkan or border states has been, and is now, and will be for a long time.



But I also ask you not to worry. You don't need to worry about these people. They are perfectly able to take care of themselves. They have not the one one-hundredth of what we have to get along with, but they have something, and it is theirs, and they are making the best use of it, and they are going after this thing, Ladies and Gentlemen, in a manner that in a very few short years will put them well to the fore, and we Americans here, who are reveling in a prosperity few of us realize or recognize, will find it very difficult to compete with them in the markets of the world.

These are a great people, and they dress rather peculiarly. In Roumania we find the home of the slit skirt. We used to find fault with the ladies for having their skirts split up to the knee on the side, but a Roumanian woman in her native costume has a white petticoat, and her dress consists of two flaps, one in front, down to her shoe tops, and one down behind. The men are also distinguished for their apparel, and you can always tell when you see a Roumanian peasant at the railroad station or on the train riding with you. You can always tell to what extent he enjoys the affection of his life. Because they wear, contrary to our custom, their shirttails outside, whereas we wear ours inside, and those who are thought well of by their wives have their shirttails embroidered in the most beautiful manner. And therefore my impression was that if a man did not have—if his shirt-tail was plain, his wife either thought nothing of him, or he had none. But when I saw a man with the most beautiful embroidery that any woman ever looked at I made up my mind that his wife was a jewel, and was sure that he had one.

Now it is curious, but these things don't offend you at all. Really, I wonder why you don't do this thing yourself. Roumanians are wise people. When they want a thing they want it.

Down in Bucharest I found them jealous of their Polish neighbors, because a gentleman from this sleepy city sometimes called Sleepy Hollow had undertaken to trust the Polander for 150 locomotives, and the Roumanians wondered why the same gentleman who was now in their midst couldn't accommodate them in like manner. Well, of course, they hadn't heard that the War Finance Corporation had blown up and they hadn't heard that money was growing more and more difficult to obtain in this country, but they wanted engines, and it was up to this Philadelphian to devise some means whereby they could get locomotives.

When William Penn came to Philadelphia he treated with the Indians in about the same manner that this same Philadelphian went to Roumania and treated with the Roumanians. The Indians had no use for money, but they did admire the things which William Penn brought over, and they were willing to accept those in barter for things which they could give to him, for land or for skins or other goods, and so in Roumania the first thing which occurred to me was perhaps I might give these people some locomotives for a cargo of glass beads, because I noticed in my office, have noticed for the last year or two, when the girls have nothing else to do they are busy making purses and sewing glass beads all over them, and figuring up the fifty million women in this country and each making one of these bead purses, I felt that we could stand a few shiploads of beads about as well as we could stand anything else. (Laughter.) But as the bead business wasn't good over there, I found the petroleum business was, and after consultations with the ministers and with the King and the Queen, who is a good business woman—in fact, the best business man in Roumania is the

Queen—we arrived at a barter by which we would send them locomotives and they would turn over to us oil.

The question of money was not mentioned excepting that the Finance Minister finally desired the privilege of paying in money or American dollars if he could find any.

Now, my impression there was that these people knew what they wanted and they were willing to accept any reasonable proposition that would place in their hands these locomotives, and now, why locomotives? Because I realized that those peoples in those countries had no use, had no need for our charity, they didn't want it; they didn't want your bacon and eggs; they had plenty of bacon and eggs themselves. They had plenty of wheat in the fields, they could raise all that they could eat and all their friends could eat if they only had something that would carry this food from one place where it was raised to another place where it had to be eaten. If they had locomotives that would carry the oil from the oil fields to the port of Constantinople they could ship it and realize on it. They wanted locomotives to haul lumber from their fine forests to the shores so that England could get it and England was crying for it. To take salt from their salt mines, the finest in the world, so that the price of salt in the civilized nations would fall, and Roumania would prosper from the money which she would get. The locomotive was the key to the situation.

Now that was the chief impression that I got, and the impression I might say impressed me very favorably. So I traveled along and concluded I would go down into Serbia and see what the Serbians looked like. Now I imagined that Serbia was a country that nothing but a goat could travel in, that the mountains were precipitous and the paths narrow and the people were an uncomfortable and not at all genial lot to deal with. In going down to Belgrade I passed through the most beautiful pastoral country that I ever went through. There isn't any land in this country, unless it be Lancaster county, which will this year raise a tobacco crop of over twelve million dollars that could compare with it. I had read in the newspapers for several years of the devastation of this country, of the killing off of all its flocks, of the destruction of its houses, its fields, its roads, and everything else. I never saw such herds of cattle, not even in the Wild West. I never saw such beautiful flocks of sheep. I never saw such beautiful farm hamlets, places for farmers and their families to live in and in one field alone, a good-sized field, I counted twenty-eight ox teams with six pairs of oxen in a team plowing—in a country devastated by five years of war.

Now, probably the troops didn't pass through that particular section, but in Belgrade, which was all shot to pieces, the people were just the same as they were in Bucharest, they were just the same as they were in Poland, they were on the alert, they knew their troubles and they were cheerful over them. And, therefore, it behooved me to find out what they wanted to do. And a tentative arrangement was made to barter for wheat. The impression I gained was that Belgrade or Serbia did not really recognize what her natural products were to her; neither did they in Roumania, and I said, "Why don't you put your finger on these and use them to build up your country, and not allow the speculator to come in and buy this product of yours in your own coin, at a low rate, and ship it out of the country and sell it at an enormous, outrageous profit to those who are anxious to get it," and when I told him the price which I could afford to pay, delivered at Trieste, for wheat, which all I would have to do will be

put it in a vessel and send it around to Belgium, they were astonished, and they said, "If you can pay us that for wheat we will immediately give you an order for all the locomotives you can build." But I told them that I couldn't build very many, that we had to build for everybody and we could only do a little.

Now, coming home, back through Paris you could see the gradual increase of industry in passing through Italy—Italy had barely started to get rid of the remnants of war, the wire and the guards that had been put over the battlefields, the trenches were unfilled, but the reason for that was that the ground was not as fertile or as well inclined to produce as the land in these other countries, especially in France, and the nearer you got to France, the more you realized that the people of Europe could take care of themselves, all they needed was assistance from us in the way of providing them with the machinery and the raw materials with which to commence and for those we would have to find some way of establishing our credit and giving these people time to earn the money with which to repay us for the start which we would give them, and that way is being found, not only by the little company which I represent, but by almost every manufacturer who has been induced to take any interest in the affairs of Europe.

Crossing over the Channel into England one's feelings received a check. I was not at all pleased with the attitude of labor toward capital or capital toward labor that I found in this country. I was not at all pleased with the attitude of the average citizen and working man toward his country. There was a fence up and a very high fence, and a discontented lot of people on either side of the fence, and that is still continuing, and in this recent development where everybody in America who had loaned Poland a dollar was shivering whether Poland would be whipped and wiped off the map in a minute, were trembling in their shoes, England was afraid to put out one single helping hand on account of the Bolshevism which was raging and liable to break loose in that country, and to France alone is the honor of taking a firm stand and long before the Bolshevists approached Warsaw to have started on the way the necessary machinery of war which, under the guidance of a most able French general, was to envelop the Bolshevist army the same as Joffre enveloped the German army outside of Paris in the early years of the war. France, therefore, today, in my judgment, and it is the impression which I formed over there, and which has been further confirmed by the report of one of my people whom I sent specifically to inquire into this matter, is today the dominating state of Europe, and Belgium is her ally, and will be her ally. Together those two states are going to lead Europe out of its trouble and put it safely on its feet. Those, gentlemen, are my impressions from abroad, and, returning home, is it but natural that I should form some new impression of my own country, and what we ought to do? Especially here in Philadelphia, the leading manufacturing city of the United States, we manufacture almost everything here, from ladies' stockings clear down to such a lot of common ordinary things—why, we have been in the manufacturing business over here ever since we started. What other things do we manufacture? I think I have stated it once before to some of my friends in Philadelphia—we manufactured the Declaration of Independence here in Philadelphia, and we manufactured here in Philadelphia the Constitution of the United States, and we further manufactured here in Philadelphia down on Arch street, and the house is still standing, the American Flag.

which every American citizen has learned to love and respect. (Applause.) And the other evening I heard a speaker say something which I will never forget, that in a certain newspaper in New York he saw a flag and this flag was supported and held aloft and there wasn't a star on it, there wasn't a stripe on it, but there was on it "The League of Nations or Nothing." Now, we manufactured the American Flag in this city, and I guarantee you that there are enough true Americans in this great United States, and if they are not in the United States, there is in Pennsylvania enough true Americans to uphold that Flag which we manufactured, to put it up and hold it there, despite any other flag which may be manufactured for the whole United States. (Applause.)

And why, gentlemen and ladies, do I say this? I say this because I have a profound impression of the greatness of Pennsylvania. We always used to hear Pennsylvania called the "Keystone State," but the last war demonstrated the one fact that Pennsylvania was the Keystone State of this country. Pennsylvania furnished one-sixth of all the supplies that went into the American Army. Pennsylvania furnished the majority of all the steel that was employed. Pennsylvania furnished all the heavy artillery or practically all—the only heavy artillery that went into France and into action came from the banks of the Delaware. Seventy per cent of all the military rifles that our soldiers carried were manufactured here in the East out of Pennsylvania steel, with Pennsylvania workmen, and at Chateau Thierry Pennsylvania men with Pennsylvania rifles turned the troops of Germany back.

Now, this is a little bit only, because last year when the Government after a wild orgy in the way of expenditures and the greatest taxation that this country has ever suffered from, Pennsylvania paid more than one-sixth of the national tax, and that after having furnished more than one-sixth of the soldiers which went into the American Army. And what now will Pennsylvania do? Pennsylvania is going to furnish one-sixth or more of all the necessities of a war, a war among ourselves, to restore the United States to what it was before the war, before we had such things to endure as we have had during the war and since the war. Gentlemen, the effort of Pennsylvania—and it will be no mean effort—will be to put Pennsylvania and the whole of the great United States once more back on the pike and not on a detour. (Prolonged applause.)

NOTICE

CHANGE OF HEADQUARTERS

Beginning November 20th, 1920,
address all correspondence to

AMERICAN SOCIETY FOR STEEL TREATING

4600 Prospect Avenue
CLEVELAND, OHIO

FUELS AND THEIR APPLICATION TO METAL TREATING

By W. A. Ehlers.*

(A paper presented at the Philadelphia Convention.)

The science of metal treating is unquestionably one of the most interesting and important subjects in the mechanical field today, and one which calls for the most careful and comprehensive study and application, if correct results are to be secured.

Metal treating has come into greater prominence in recent years, due in a large measure to the ever increasing demand for lighter, yet stronger and more durable moving parts in all forms of machinery subjected to unusual wear or shock, and also on account of the great development in automatic and special machinery.

Unfortunately many shops are still treating tool steel in the old blacksmith forge, which is as much a relic of the "dark ages" as the ox cart is in the field of rapid transit. Steel cannot be successfully treated in the coal forge, due principally to the condition of uneven heating. Uneven heating produces uneven cooling, which in turn produces uneven stresses in the piece when it is quenched and hence will shorten the life of the finished part.

A uniform temperature throughout the entire heated area is necessary, if correct results are to be obtained. It is surprising to find that many practical steel treaters continue to use the old and crude method in treating expensive steel, because they do not see the wisdom of purchasing modern furnace equipment, which will give better results and greater economy, by prolonging the usefulness of the tool.

It is of interest to note that many of the manufacturers of so-called "special steels" for tool making purposes, recommend that they be heat treated in gas fired furnaces.

Certain fundamental conditions enter into the processes of metal treating which are of great importance. One of these is the necessity for obtaining uniform results, and the elimination of the possibility of producing work below the required standard. To obtain uniform results it is very necessary to regulate, and maintain the temperature of the furnace within a reasonable degree of that required for the particular operation. This imposes the condition that the fuel must be of such nature that the amount of heat delivered can be changed very quickly. It is also necessary to have positive control of the furnace atmosphere.

The ideal furnace is one which maintains an evenly distributed heat throughout the parts to be heated, when loaded to its capacity, and one in which the temperature and combustion products are under positive control.

From chemistry we learn that **matter** may be defined as that which ocupies space; that matter is composed of infinitely small particles known as molecules. Molecules are again composed of atoms, and these combine to form elements or compounds. Thus like atoms will form an element, and when combined with atoms of other substances they form a compound.

It has also been proven by experience, that the molecules of all matter are never at rest, but are always in motion and the motion of these molecules produces heat, therefore the greater the activity of the molecules, the greater will be the amount of heat produced, all other things remaining unchanged.

Moreover each combustible substance has a definite temperature of

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ignition and when certain of these molecules reach the temperature of ignition they have a great affinity for oxygen. The resulting chemical union between these atoms gives rise to what we term combustion. Combustion has therefore been defined as "the phenomena produces on the surface when two substances unite to give light and heat."

In a further study of combustion there are certain fundamental factors and conditions to be met if proper combustion is to be obtained and the resulting heat properly applied. All fuels are made up of combustible substances, each giving a certain definite temperature of ignition and each forming a new compound when mixed with the proper amount of oxygen at the point of ignition. This leads to the conclusion that perfect or complete combustion can take place only when these substances are mixed with oxygen in the proper proportion. Or, stated in more familiar terms, a definite amount of air is required to completely burn a given quantity of fuel.

The properly designed furnace is an important factor in heat treating. Time will not permit me to go into this very important subject. Poorly designed furnaces are not only uneconomical but they are largely responsible for unsatisfactory results. Many furnaces are operated without knowledge of the composition of the furnace atmosphere; with no control of the air supply or flue gases. There are certain fundamental principles such as type of construction, kind of fuel and the means of utilizing the heat of combustion that govern the design, but in general the character of the work to be performed, the kind and quantity of materials to be treated are the controlling factors. The real test of a furnace for a given operation is "the variation in temperature in all parts of the furnace around the mass to be heated when the chamber is loaded to full capacity."

One of the things first to be considered in the proper heat treatment of metals is the kind of fuel necessary to produce the character of heat best suited for the particular operation. Unfortunately there is a prevailing belief among many that when it is desired to heat treat a piece of steel the only thing necessary is to build a fire and plunge the material into it. If results are not forthcoming they blame the steel perhaps and not the method, which, in most instances, is the real cause.

For all practical purposes fuels may be clasified into solid, liquid and gaseous. It must be remembered that in the case of solid and liquid fuels, each must first be converted into gas before combustion really takes place, and for this reason they are not so easily adapted to exact furnace conditions and temperature control.

Of the solid fuels, coal and coke are principally used. Lump coal and coke are not very well suited for metal treating operations, except in very large furnaces for pack annealing and case hardening in large quantities. Even with these it is not easy to maintain a uniform temperature, and there is great danger of overheating. At best they are very wasteful of fuel, and it is difficult to control the products of combustion which is particularly essential where the metal is subjected to the direct action of the flame.

Powdered coal has a great advantage over lump coal or coke in that it may be termed a "one stage" combustion being complete and free from residual carbon. It burns directly to CO_2 without the attending losses of unburned carbon and carbon contained in the ash. Its chief disadvantage, however, lies in the mechanical preparation of it, as it must be crushed, thoroughly dried and stored, also in the harmful action of the ash upon furnace walls and linings.

Liquid fuels generally exist in the form of kerosene, gasoline, and fuel

oil. Owing to the great demand for kerosene and gasolene for internal combustion engine and other purposes, their cost has advanced to such a point that they cannot be considered for the heating of furnaces. Fuel oil as a general rule is more expensive to use than coal or coke, but its superiority over these fuels in its form of application to the furnace is sufficient to overcome the increased cost. Fuel oil is a by-product of crude oil refining, and its cheapness in the past has been due principally to crude methods in refining and an over production of crude oil. With the increasing demand for motor fuel, improvements have been made in refining methods, which have very materially reduced the fuel oil available for metallurgical purposes. This situation is largely responsible for the scarcity of fuel oil and the unprecedented high price, and according to reliable authority, including the U. S. Bureau of Mines, very litttle hope is given that it will be any cheaper for sometime to come.

A good grade of fuel oil will range from 18,500 to 20,500 B. t. u.'s per pound, and a vaporizing point of about 170° F. Considering that air is composed of 20.7 parts oxygen and 79.3 parts nitrogen, one pound at 62° F. occupies a space of 13.141 cubic feet, and at 100° F. one pound occupies 14.096 cubic feet. Theoretically it requires about 14 pounds of air to give perfect combustion of one pound of oil. Therefore it will require 14×14.096 or 197.34 cubic feet of air to burn one pound of oil at 100° F. However, in practice it requires from 17 to 20 pounds of air or in round figures 2000 cubic feet of air at 100° F. to completely burn one gallon of fuel oil.

In admitting oil to the combustion chamber of the furnace it must be broken up into a fine spray, commonly spoken of as atomized, by means of a suitable burner. Atomization may be obtained in one of three ways:—Live steam, compressed air, and mechanical process. Of these compressed air is more generally used.

Where air is used for atomization it is usually found to vary in pressure from 1½ pounds to 60 pounds per square inch, depending upon the kind of burner used. The majority of installations work with an air pressure of about 20 pounds per square inch. This, however, is higher than necessary for good results. With air under a pressure of 20 pounds per square inch and oil at 100° F. there is required about 50 cubic feet of air per pound of oil.

Steam for atomizing is not so generally used in industrial operations, due perhaps to its greater cost over compressed air. Moreover in many places it is not available. According to Durand, 0.4 pounds of steam are required per pound of oil. This agrees closely with some investigations reported to the American Society of Mechanical Engineers (Aug. 1911 Bulletin) which give an average of 0.5 pounds per pound of oil. The latter is perhaps a safer figure to use.

Fuel oil often contains a small percentage of water which lowers its heating value. For each one per cent. of water the heating value is reduced 13.14 B. t. u.'s. Thus for an oil having nominally a heating value of 18,500 B. t. u.'s per pound and containing 10 per cent water the heating value is reduced to 16,518.6 B. t. u.'s or a loss of 1982 B. t. u.'s. If water is in the oil, combustion is incomplete, the violet flame never appears, but the end of the flame will be dark red and fringed with smoke.

Fuel oil being rich in hydrocarbons, gives a very high heat for a comparatively small volume of oil. For this reason it is particularly adaptable to heavy forging work, such as drop forging; the heating of

heavy bars and rods for forging and upsetting. It is also a very excellent fuel for welding.

But there are many things which must be considered before selecting oil as a fuel, particularly on the purely heat treating operations. There is the necessity for a large and expensive storage tank which must be buried in the ground. This tank frequently leaks and much oil is wasted before the leak is discovered. Smoke, grease and the roar of burners under high pressure are serious objections, and these are not conducive to making the surroundings pleasant for the shop men.

Moreover the use of oil does not permit of automatic temperature control by placing a thermovalve in the fuel line. Conditions affecting a continuous supply are not the best and frequently much time is lost waiting for a new supply.

Gases which are most generally used for fuel purposes are natural gas and the manufactured gases such as coal gas, coke oven gas, water gas and producer gas. These gases are pre-eminently suitable for and by far the most satisfactory fuel for metal treating processes. These facts combined with the economic advantage makes gas the coming fuel of the future.

Gaseous fuel is economical, because it can be applied in a way most adaptable to the requirements of the material to be heat treated. Other fuels as a rule must be burned in the furnace in a certain fixed way, there is very little flexibility in their application. Gas on the other hand can be applied in a way that will give the best result with the least waste of fuel.

By its nature and composition gas offers the greatest advantage from a purely scientific point of view. It is easy to thoroughly mix it with the proper amount of air for complete combustion. With other fuels this is impossible. Control of the air-gas ratio means a higher rate of combustion, a relatively higher flame temperature, and therefore a higher thermal efficiency.

The cheapest fuel, even with other things being equal, is not necessarily the one which gives the greatest number of B. t. u.'s per unit of cost, but the one which costs less per unit of production. Numerous examples can be given to prove this statement. However, one or two should be sufficient. In a certain town in the state of New York gas selling at a rate of approximately one dollar per thousand cubic feet replaced soft coal at about five dollars per ton for bright annealing copper wire. It was first demonstrated in an experimental way that coal was the most expensive fuel for this particular operation, although it contained perhaps four times more B. t. u.'s per unit of cost than found in the gas. It further demonstrated the fact that the thermal efficiency of the gas furnace was several times greater than the coal furnace.

A large oil producing and refining company used large quantities of manufactured gas for heating solder baths at their refinery, where there was almost an unlimited quantity of crude oil, fuel oil, gasolene and kerosene.

The industrial heating department of a large and well known gas company found from actual operations that under the best conditions of oil utilization they could substitute 1000 cubic feet of a 600 B. t. u. manufactured gas for 5½ gallons of 142,000 B. t. u. oil. Where oil was used at a low efficiency this company found that 1000 cubic feet of 600 B. t. u. manufactured gas could be substituted for 14 gallons of oil of 142,000 B. t. u.'s per gallon.

In other situations the same company was able to substitute 126 B. t. u.'s of manufactured coal gas for 210 B. t. u.'s of producer gas. Again, 253 B. t. u.'s of manufactured coal gas gave the same results as 504 B. t. u.'s of producer gas.

The above occurrence confirm the statement that fuels cannot be compared in relative heating value by their B. t. u. content in the fuel state. The only correct basis of comparison is the heating value of the combustible mixture. This fact is well established theoretically. A few calculations will show that a coke oven gas of 600 B. t. u.'s per cubic feet will give a theoretical flame temperature of 3550° F. and a heat content of 100 B. t. u.'s per cubic feet in the products of combustion. While a blue water gas of 300 B. t. u.'s per cubic feet will develop a flame temperature of approximately 4000° F. and a heat content of 107.5 B. t. u.'s per cubic feet in the products of combustion.

Yet in the face of these facts, both theoretical and practical, we find many practical steel treaters in favor of coal and oil because of their erroneous belief that the B. t. u. value of the fuel as fired to be the real measure of its utility.

The principal combustibles in the fuels under consideration are carbon, hydrogen, and their many combinations known as hydrocarbons, also carbon monoxide. In addition to these are the incombustible such as nitrogen, oxygen, sulphur, carbon dioxide and ash. The combustible elements when mixed with air give a flue gas composed of carbon dioxide, water vapor, sulphur dioxide, nitrogen and carbon monoxide. Furthermore by changing the proportion of air in the flue gases gives rise to three general conditions within the furnace:—a reducing, neutral, or oxidizing atmosphere. These conditions are essential and are of great importance in different heat treating processes. They also have a very vital relation to fuel economy and furnace efficiency.

A reducing atmosphere (one in which an insufficient amount of oxygen has been admitted with the fuel to give complete combustion), is a condition often desirable in heating tool steel and other steel parts, in order that no oxidization or scaling action shall take place. The flue gases should show a small percentage of unburned gases.

A neutral atmosphere is one which is hard to obtain with any of the fuels except gas. It represents a condition in which just enough oxygen has been admitted to completely burn the carbon hydrogen, and other combustibles present. In this case a flue gas analysis will show no free oxygen or unburned gases.

The condition most frequenttly found in furnaces is the oxidizing atmosphere, where an excess of oxygen is necessary to accomplish certain results, or where too much has been admitted through poorly designed apparatus. This condition is very noticeable in coal fired furnaces, where it is necessary to burn the coal with a large amount of excess air. Such a condition within the furnace is harmful in many ways. It causes over ventilation and thus carries away much of the sensible heat of the unburned gases. It produces a chilling of the flame, lowers the temperature of the furnace, and thus reduces its thermal efficiency. Steel exposed to this furnace condition oxidizes very rapidly.

For industrial heating operations, gaseous fuel should always be mixed with air before the gas has reached the zone of combustion, and in the proper proportion to give the desired furnace atmosphere. For all metal treating work, some mechanical means should be used to produce air at sufficient pressure, and thoroughly mix it with the gas. This

is of great importance in burning gas. Many devices are used, but all may be grouped under three general types.

(1.) The Air Injector—air under a pressure of a few ounces to one or two pounds per square inch is passed through an injector. Gas is admitted to a chamber surrounding the injector and the high velocity of the air in passing through the injector opening entrains the gas and the mixture is then led to the burner. This method requires both air and gas piping to the injector. It further requires valves on both the air and gas pipes and these are changed by the furnace attendant to give the desired mixture.

(2.) Gas under relatively high presure—under a pressure of from 8 to 10 pounds per square inch gas passes through a small orifice, and entrains air under atmospheric pressure. The resulting mixture is led to the burner located nearby.

(3.) Gas and Air Mixing Machines—a machine designed for this special purpose is located at a convenient point. Air and gas are brought together inside the machine in any predetermined proportion within the limits required for combustion. By means of a pump or fan the mixture is distributed from this point by means of a one pipe system to the point of consumption.

It is to be regretted that in the majority of gas fired furnaces the air injector is used for mixing. This is largely due to a lack of initiative in the past on the part of gas engineers, and also on account of the ease with which an injector may be constructed. We have no particular antagonism to the air injector as a mechanical means of mixing the air and gas, but the greatest evil lies in the very uncertain proportions of air and gas thus obtained by means of manual adjustment of the valves usually administered by unskilled furnace attendants. It is no exaggeration to say that the ordinary furnace fitted with an air injector and a two pipe system, and operated by the average furnace attendant will use as much as 50 per cent. excess air.

With the high pressure gas inspirators and air-gas mixing machines it is very easy to make adjustments that will mechanically control the air-gas ratio to give the desired furnace condition. After this adjustment has been made it is only necessary for the furnace attendant to regulate one valve in order to give more or less heat as the occasion may require.

The application of heat in furnaces to the metal to be treated is another subject of great importance and one too often overlooked. Heat may be transferred from one body to another, or applied to a body from the point of combustion in three different ways:—by conduction, convection and radiation.

Heat transfer by conduction takes place when it is transmitted from one part of a body to another without the occurrence of motion in any definite part or parts of the body intermediate points being heated meanwhile. Thus a steam radiator becomes hot on the outside due to **conduction** of the heat of the enclosed steam within the radiator which passes through the iron to the exterior. Placing one's bare foot on a tile floor in a room well heated will give the impression that the title is very cold. While if the foot is placed on a rug it will feel much warmer. As a matter of fact the tile and rug are perhaps of the same temperature, but the tile being a much better conductor than the rug, absorbs the bodily heat from the foot much quicker than the rug and is therefore known as a good **conductor.**

Heat transfer by convection takes place when it is conveyed from one place to another by the movement of air currents, or the circulation of liquids. When heat is applied to the bottom of a pan of water, almost instantly minute vapor bubbles form in the bottom of the vessel. These presently ascend and impart heat to other parts of the water, while cooler water takes its place at the bottom.

Heat transfer by radiation takes place when heat is transferred from a hot body to a colder one by a wave like motion of the ether that occupies all space. The ordinary cast iron steam or hot water radiator warms the room by reason of the fact that the heat of the radiator starts a wave like motion of the surrounding ether in all directions, and as these travel outward from the radiator, similar to the waves of water when a stone is thrown into a still pond, the heat is imparted to the room, and this transfer of heat is called radiation.

For all practical purposes of furnace design, the heat of combustion is transferred to the material to be heated by means of convection and radiation. Heat transfer by conduction is to be avoided as much as possible for by this means the efficiency of the furnace is very much lowered if heat is allowed to be conducted through the furnace walls and lost. For this reason it is important that all furnaces should be thoroughly insulated with the best kind of nonconducting material, in order to reduce such losses to a minimum.

In the usual type of furnace, the heat is transferred by convection to the walls and arched roof, and from these a radiant heat transferred to the material to be heated. Then in order to get the maximum amount of radiant heat from the gas burned, there must be as near complete combustion as possible with a minimum amount of flue products.

The proper furnace conditions are hard to obtain with any degree of certainty or uniformity when coal, coke or oil are used to produce the heat. On the other hand, gas on account of its flexibility of application, can be made to accomplish far better results.

Coal and coke are seldom considered today in connection with the larger and more important heat treating operations, because of the difficulty in maintaining proper furnace conditions.

Oil can no longer be considered a cheap fuel for furnace heating on account of the economic demand for it for other purposes.

Natural gas supply is continually growing less, as evidenced by the increase in shortage during the winter, and the construction of manufacturing gas plants to augment the supply.

Producer gas plants and others that use coal at the sacrifice of the valuable by-products will sooner or later go into the discard.

It is possible we are approaching the dawn of a new day in industrial economy. A day when the gas manufacturing company will become a central fuel station from which can be supplied the entire fuel demand for industrial heating. But on account of the ridiculously unreasonable standards of candle power and heating value placed upon the gas companies by the State Utility Commissions in the past it has not been possible to produce a gaseous fuel of the greatest economic advantage.

The question of fuel costs is a very vital one to every manufacturer. Unfortunately a decision has often been reached on a purely heat unit basis, without considering the efficiency of application, and many items of expense incurred in handling such fuels before they reach the zone of combustion.

In the foregoing remarks the aim has been to state a few of the char-

acteristics of each fuel together with some of their advantages and disadvantages. It must be remembered that the true fuel cost is not the cost of coal per ton, oil per gallon or gas per thousand cubic feet delivered at the factory, but rather the cost of these fuels delivered to the hearth or burner of the furnaces.

There are many items of expense such as the handling of coal, removal of ashes, investment in storage equipment, labor, time lost in getting started with coal or oil, the noise and smoke nuisance so peculiar to the oil fire, and the deteriorating effect of coal and oil on the furnace causing frequent repairs. The proper fuel is the one which regardless of cost per ton, gallon or cubic foot, gives the correct heat application, perfect combustion, and proper temperature control.

Therefore in the final analysis the true furnace efficiency is measured by the quality of the work it produces and the cost per unit of product, and not upon the relative cost per unit of fuel consumed.

MICROCONSTITUENTS IN ONE SECTION OF A METCALF TEST BAR

By Oscar E. Harder, Ph.D.*

The test which has come to be known as the "Metcalf Test," was originally outlined as follows:[1] "To show this effect we take a bar of steel of ordinary size, say about inch by half, heat six or eight inches of one end to a low red heat, and nick the heated part all around the bar, at intervals of half to three-quarters of an inch, until eight or nine notches are cut. This nicking is done at a red heat to determine the fracture of the nicks. Then place the end of the bar in a very hot fire, leaving the balance of the bar so much out of the fire as to heat it chiefly by conduction. Heat the end of the bar in the fire to white hot, or until it scintillates, and allow it to remain until the nick furthest from the end in the fire is not quite red, and the next barely red. Now, if the pieces be numbered from one to eight, beginning at the outer (hot) end,

No. 1 will be white or scintillating;
No. 2 will be white;
No. 3 will be high yellow;
No. 4 will be yellow or orange;
No. 5 will be high red;
No. 6 will be red;
No. 7 will be low red;
No. 8 will be black.

As soon as heated as above described, let the bar be quenched in cold water, and kept in the water until quite cold."

The information which Mr. Metcalf considered could be obtained from this test is indicated in the following quotation: "First: (a) A difference in temperature sufficiently great to be seen by the color will cause a corresponding difference in the grain. (b) This variation in grain will produce internal strains and cracks.

"Second: A temperature so high as to open the grain, so that the hardened piece will be coarser than the original bar, will cause the hardened piece to be brittle, liable to crack and to crumble on the edges in use.

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1. Metallurgical Review, vol. 1, pp. 245-253 (1877-8).

"Third: A temperature high enough to cause a piece to harden through, but not high enough to open the grain, will cause the piece to refine, to become stronger than the utempered bar and to carry a tough, keen cutting edge.

"Fourth: A temperature which will harden and refine the corners and edges of a bar, but which will not harden the bar through, is the proper heat at which to harden taps, rose bitts and complicated cutters of any shape, as it will harden the teeth sufficiently without risk of cracking and leave the body of the tool soft and tough, so that it can yield a little to pressure and prevent the teeth tearing out."

Since the original test was described it has been used extensively for demonstration purposes in educational institutions and shows to the students, in a very striking way, the effect of temperature on the grain size and hardness of steel.

This test has an additional use in that it may enable the practical shop man to determine experimentally the temperature, as judged by the eye, required to give the best refinement of the grain in a particular steel and, therefore, enable him to judge with a reasonable degree of accuracy the proper temperature for heat treating that steel.

So far as is known to the writer, the microconstituents of what may be termed the "critical section" (i.e. the section which has been heated to just above the upper critical point) of the Metcalf test bar have not been published, and it is that feature of the test which is to be considered in the following notes.

The steel used in this test contained 1.17% carbon and was ¾-inch round open hearth steel. The test was made about as recommended in the directions quoted above and the microconstituents of this particular section carefully studied.

Figure No. 1 shows the fracture, at a magnification of four, of the end of this section which had been heated to the higher temperature. It is evidently over-heated and the grain coarsened as a result. Fig. 2 shows the microconstituent found at this end of the bar and is evidently martensite. This, of course, is exceedingly hard and brittle. The relative positions of the photomicrographs represented by Figures 3 to 10 are

Fig. 1. Fracture × 4

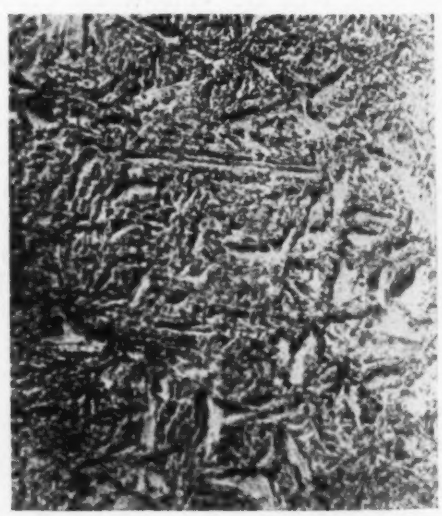

Fig. 2. Martensite × 800

shown in the following table in which the distances from the over-heated end of the bar are measured in millimeters.

Figures	Distance in mm.
3	6
4	9
5	11
6	18
7	21
8	26
9	24
10	27

Fig. 3 shows the beginning of the appearance of troostite—the dark areas. In Fig. 4 troostite predominates and the martensite (light portions) occupies probably not over 25% of the area. In Fig. 5 the martensite has completely disappeared and the whole mass appears to be troostite. Fig. 6 shows troostite and excess cementite, as would be expected in a hyper-eutectoid steel containing 1.17% carbon. Fig. 7 has been termed osmondite because of the readiness with which it was attacked by acid. Some authors do not recognize this constituent and there may be some question about

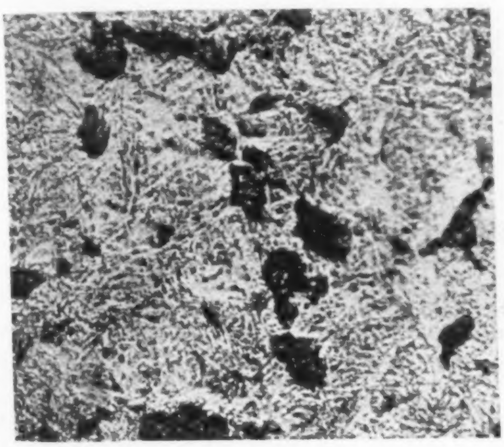

Fig. 3. M. + Troostite × 800

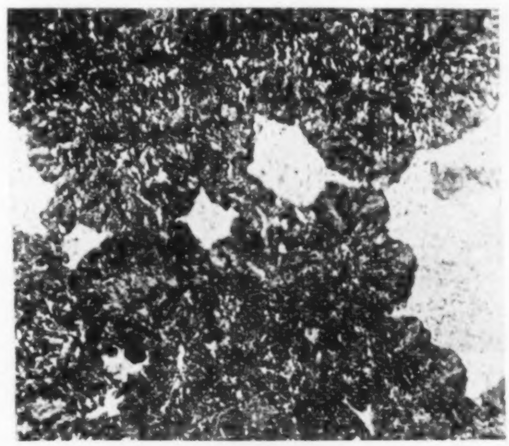

Fig. 4 + M. × 800

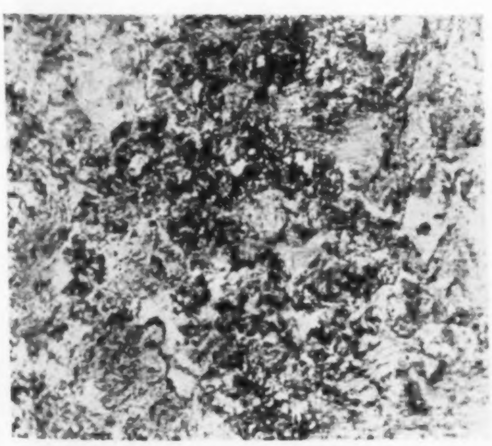

Fig. 5. Troostite × 800

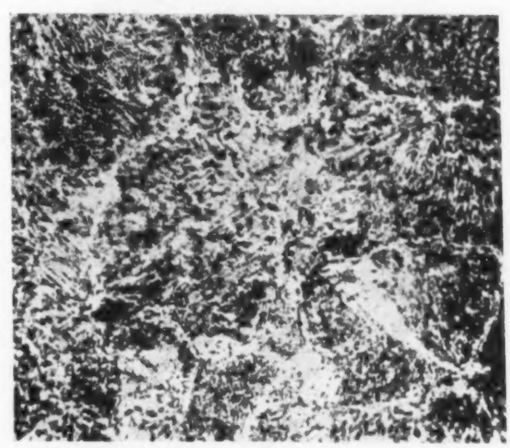

Fig. 6. T. + Cementite × 800

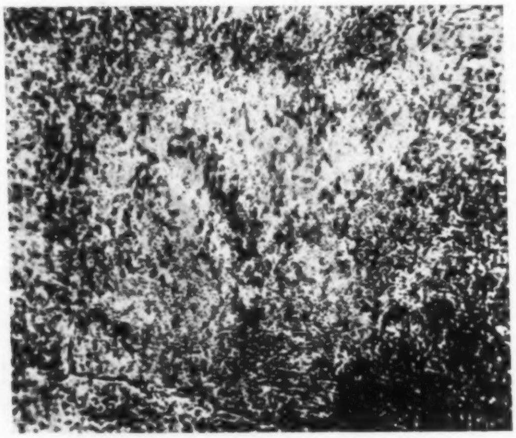

Fig. 7. Osmondite × 800

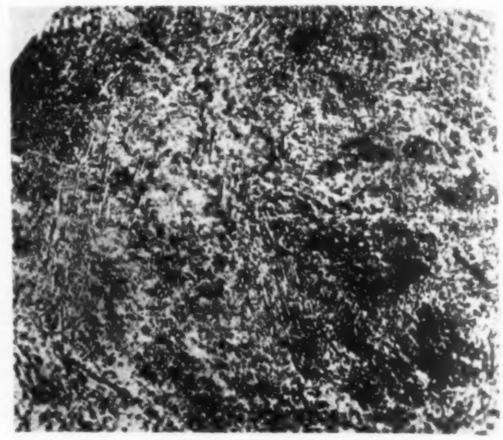

Fig. 8. Sorbite × 800

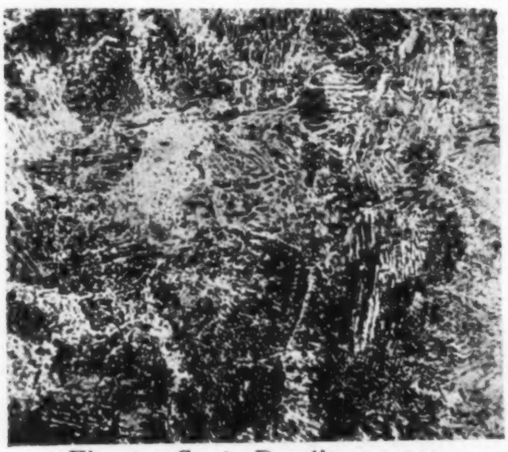

Fig. 9. S. + Pearlite × 800

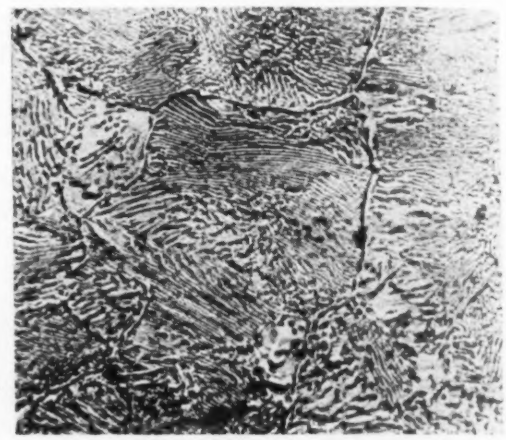

Fig. 10. Pearlite × 800

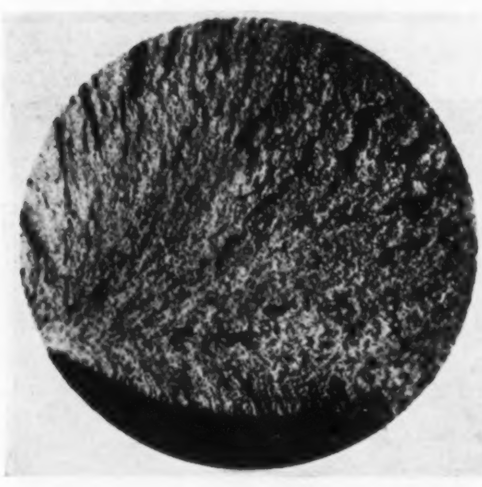

Fig. 11. Fracture × 4

Fig. 12. — Test Bar × 1

the advisability of trying to distinguish it from troostite and sorbite. Fig. 8 is a fair representation of sorbite and, doubtless, corresponds approximately to section No. 7 as referred to in Metcalf's original communication. Fig. 9 shows the first appearance of pearlite and Fig. 10 shows a field composed of pearlite with some excess cementite. Fig. 11 shows the fine

grained fracture at a magnification of four, and Fig. 12 shows the original test bar at actual size.

It probably has not occurred to most people that a small section of rod, 1¾ inches in length, when treated as is the custom in making the Metcalf test, would contain all of these microconstituents, and it is for the purpose of demonstrating that fact that this brief paper has been prepared. Most of the work was done by Mr. H. S. West, a junior metallurgical engineer in the School of Mines.

DISCUSSION OF DR. HARDER'S PAPER

CHAIRMAN: We have all listened with a great deal of interest to this presentation by Professor Harder showing the various microconstituents of the sections taken from a Metcalf Test Bar. Is there any discussion on this paper?

MR. STAGG: I was talking to a gentleman this morning and he said, "Stagg, why is it that I can cut a die from a bar, cut another die from that same bar of tool steel, and a third die from the same bar of tool steel, and give them the same treatment, and why is it that from one bar I can get a production of 100 parts, from another one 1,000, and from the third 15,000? I think those microphotographs will certainly tell that gentleman something about "Why."

CHAIRMAN: Professor Harder has traveled a good many miles to get here; I think it runs way over the thousand mark; I know he would appreciate some discussion of his paper this morning.

MEMBER: I would merely call the attention of the members here to the fact that precisely the same range of metallographic constituents can be had in as short or even a shorter space in an ordinary butt-welded piece of high carbon steel, and yet the butt-welding is done in an electric butt-welder. In welding, for instance, a piece of high carbon on a low carbon shank or making a drill bit, even though not more than a quarter of an inch at the joint is polished before any annealing is done, the beautiful range of metallographic constituents can be seen, ranging from austenitic in some cases down to the un-annealed material existing in the original bar, and in nearly every case you will find the line of demarcation from one constituent to another very well marked indeed. It is a fine example of structure for that.

MR. STAGG: A thing which I use for making the Metcalf test quite frequently is instead of taking a bar and niching it at certain points, certain prescribed distances, and fracturing and polishing, etc., is to take a short bar, notch the bar the entire length, heat it up as for a Metcalf Test to the various temperatures and then drive a wedge in and split the whole thing open. That gives me a perfect picture of the whole thing at once, and if I desire to make a micro-section all I have to do is to polish the other side of that and I have the whole story in one.

PROFESSOR KELLER: Professor, I want to state for the benefit of Mr. Stagg that that was one of the procedures followed in the University of Purdue to explain to the students the various changes that took place in an annealed state to a high temperature, and by splitting the bar you bring out very distinctly at just what position the critical range takes place.

Another noticeable fact is that if you will observe the bar closely you will see that the changes of the curve occur, naturally, on the outside first,

until it reaches or penetrates the entire bar. A very desirable length and thickness for that form of test is about four inches long, a quarter inch thick. And let me suggest that you only mark one side, and be sure that it is perfectly straight when you attempted to break it. Keep it perfectly straight before you attempt to break it. I would advise those who are attempting to use that method as a test to try that out. You will learn much about the fracture of a piece of steel.

MR. ELLINGER: For the benefit of those who will not be able to carry out such a test, either for lack of time or facilities, I want to refer you to the Proceedings of the Society for Testing Materials. I think it is the 1918 Proceedings, wherein this was very thoroughly discussed and illustrated with photomicrographs.

TIME, TEMPERATURE AND HEATING MEDIA FUNCTIONS IN HARDENING TRACTOR WORMS

By J. L. McCloud*

The rather interesting fact that it requires less time to heat a piece of Steel of any given furnace temperature is shorter, the higher the temperature, was brought out by F. C. Wagner, *Proc. Am. Soc. M. E., Vol. XXVI. Some work done by the writer in connection with prescribing heat treatment for tractor parts emphasized this fact along with some important relationships between various heating media.

This work was started in a study of the heat-treatment of tractor worms. After having experimented for considerable time with the carburizing of gear in general, we became convinced that we could get better machining qualities, enormously higher physical properties; easier heat treatment and grinding at much lower cost by using oil hardening gear stock.

At this time, let me point out that at the offset we reduced the annealing time of a .42%, .52% Carbon, 1% Chromium Steel from the customary 12 to 20 hours time to 2½ hours. The proper annealing or normalizing of a steel of this class is accomplished in three stages. The steel is first brought to a temperature of 100-150 deg. F. above its critical point on heating (which is about 1,450 deg. F.).

It is then allowed to remain at this point long enough to relieve all forging strains and for all of the carbides to go into solution. From this temperature it is allowed to cool at a definite rate to just below its critical point on cooling. At this time we found a convenient way to handle the stock was to quench it in boiling water. This enables the stock to be handled easier and in no way affects its hardness or machining ability.

The question of machinability in this material we found to be a function of the Brinell hardness, a point we watch with care and hold between the rather narrow limits of 179 to 207. All this annealing treatment we do in a push or continuous type of furnace. The furnaces themselves are described in detail by Heiser and McCloud in the June 1920 number of the American Drop Forger.

The value of a furnace of this type can be readily understood by an inspection of the figure 1, which shows the heating and cooling curves of loads of 200 and 120 tractor worm forgings (31″ each and 3½″ in diameter in the center). In reality the continuous furnace accomplishes this work in

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*Chemist, Ford Motor Co., Tractor Division, Dearborn, Mich.

so short a time as 2½ hours, due to the fact that the quantity of stock in any zone of the furnace is low and the sensible heat of the furnace body itself is utilized better, since the temperature of the furnace at any given point remains constant, as long as the furnace is in operation.

The continuous furnace has a capacity of 1900 lbs. per hour, and occupies a space two to three times that of the furnaces just mentioned, but yields about six times the work.

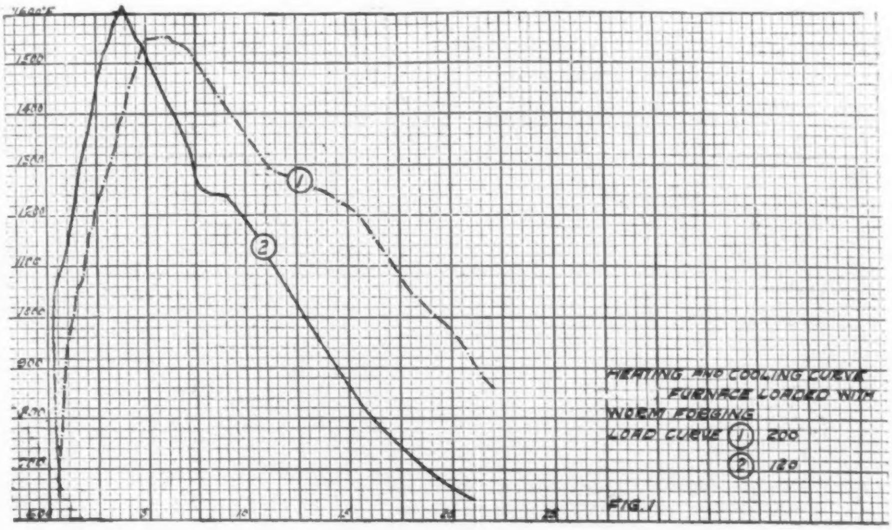


Figure No. 1

Another point of interest in figure 1, is the position of the thermocouple lag, about 1,250 deg., in both cases on cooling. This is about the same as the Ar point as determined on a single small piece of steel in the laboratory (see Griffiths Am. Soc. T. M. Vol. XVII, part II, page 33 and Fig. 8.).

In our study of the tractor worms, we found that with a piece of this large size, the ductility of a piece which was hardened all the way through

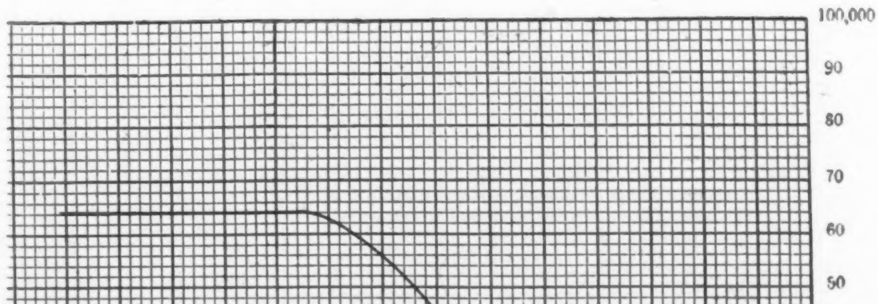


Figure No. 2

was not as high as might be desired. The figure 2 shows the stress strain diagram of a .20 Carbon Chromium Vanadium case-hardened all the way through and figure 3 a .50 Carbon Chromium Oil hardened worm hardened all the way through. To be sure the elastic limit of the oil-hardened piece is nearly double that of the case-hardened worm, but its deformation beyond the elastic limit is nil.

Being desirous of obtaining all the benefits of the oil-hardening stock cited before and at the same time to obtain the ductility of the softer stock we set out to improve the harder worm.

You will note from the figure 5 that the heating time for a single finished worm in air at 1540 deg. F. is forty minutes. The time to heat a

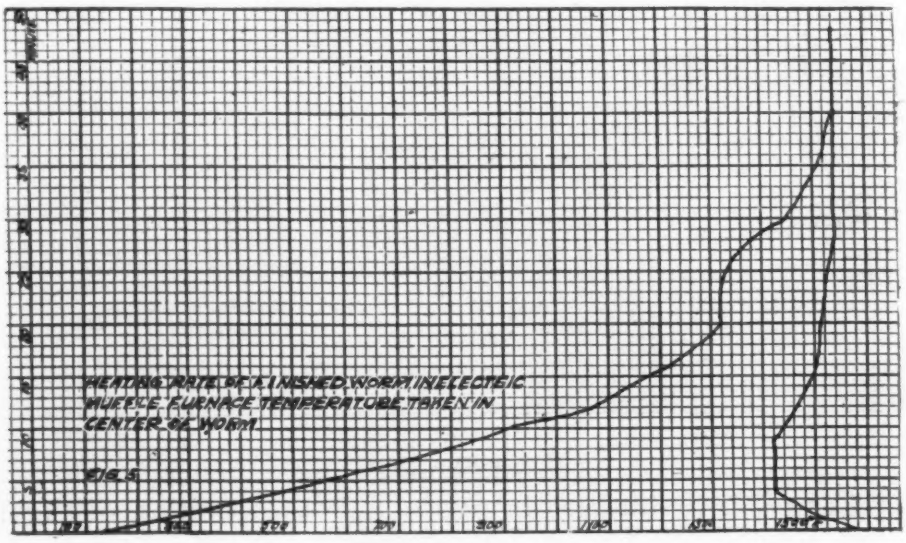


Figure No. 5

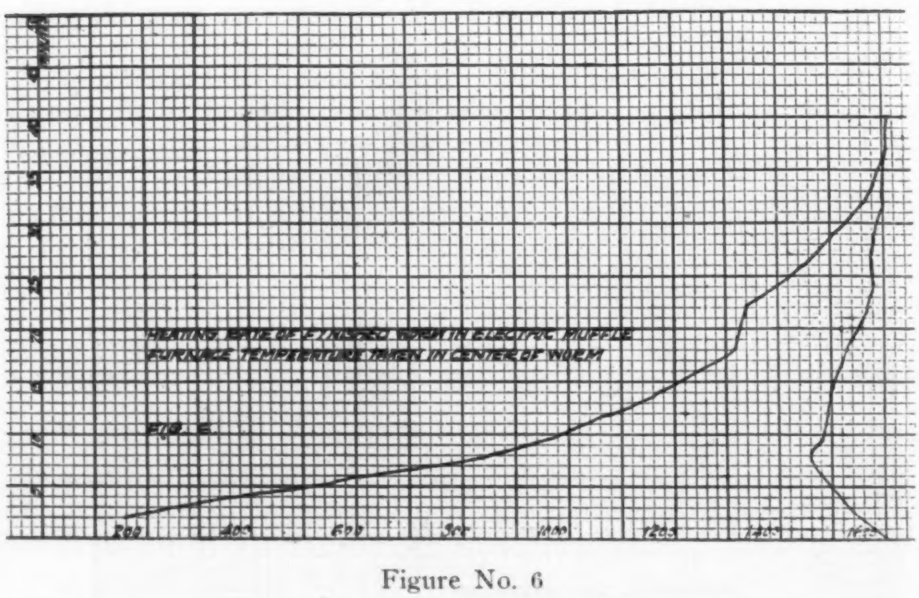


Figure No. 6

finished worm, figure 6 in air at 1600 deg. F., is 36 minutes. These curves were taken in an electric muffle furnace.

The right hand curves show the furnace temperature taken by means of a Le Chatelier Platinum, Platinum-Rhodium Thermo-couple and an

Englehard Millivolt Meter. The lower lines show the temperature of the center of the work taken by means of a similar couple and a Leeds and Northrup Potentiometer. Both curves were corrected to the same cold junction temperature of 32 deg. F. and the couples were previously checked against each other with a delicate meter graduated in tenths of microvolts.

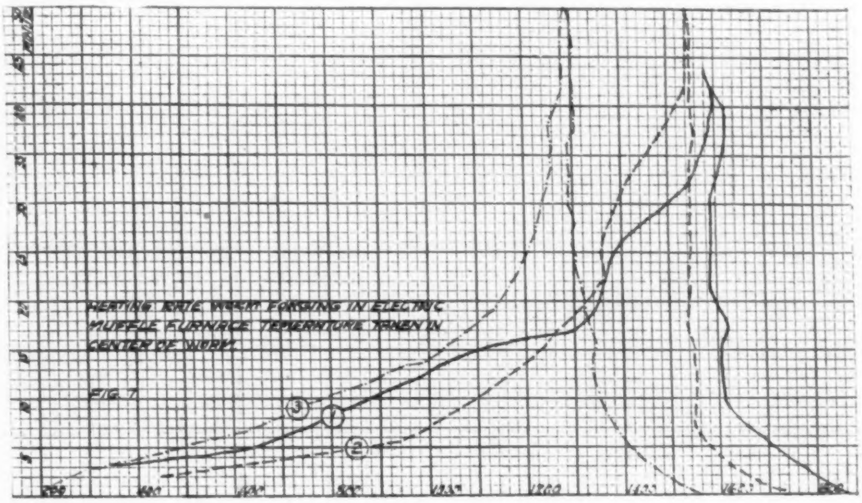


Figure No. 7

At this time let me point out that according to curves in figure 7 the statement by Wagner, cited before, requires some modification in certain cases. These curves were taken in the same manner just described, but were taken on solid worm forgings before the generation of the teeth. The solid lines show the heating time for the center of the forgings with a furnace temperature of 1600 deg. F., the dash lines the heating time for the furnace temperature of 1540 deg. F., and the dotted lines the heating time for the furnace temperature of 1300 deg. F.

You will note that the heating time to bring the forgings to a temperature just below that of any of the three say 1200 is in accordance with the statement of Wagner, namely the time to heat the forging in a furnace of 1600 deg. F. is less than that to heat to the same temperature using a furnace temperature of 1550 deg. F. and the time to heat to the same temperature using a furnace temperature of 1300 deg. F. is greater than that using a furnace temperature of 1550 deg. F.

Likewise the time required to bring the forgings to the furnace temperature of 1600 deg. F. is less than that required to bring the forgings to the furnace temperature of 1550 deg. F. But the time required to bring the forgings to the furnace temperature of 1300 deg. F. was just the same as that to bring it to a furnace temperature of 1550 deg. F.

This might be explained by the temperature lag of the forgings in the case of the 1600 and 1550 deg. F. runs due to the absorption of heat at the critical point, in which case the Ac point is clearly defined as 1350 deg. F., and which incidentally is about 100 deg. lower than that determined on a small piece by the differential method and shown in figure 8.

Figure 9 shows several points of interest and is the one that proved of greatest value to us in devising our heat treatment of oil hardening worms.

These curves were taken in a molten salt bath of the composition 50%

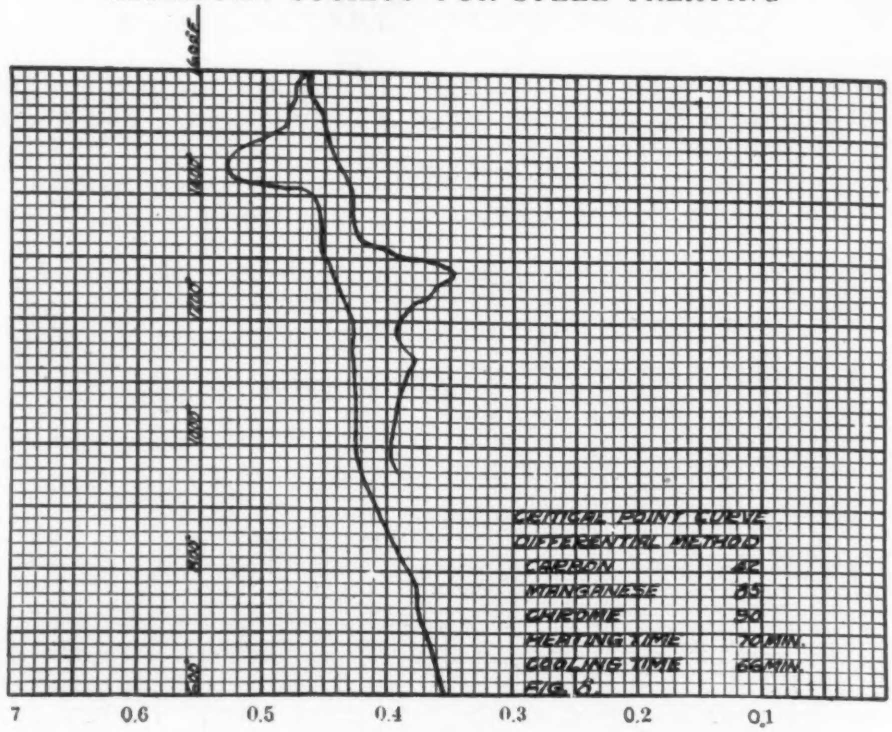


Figure No. 8

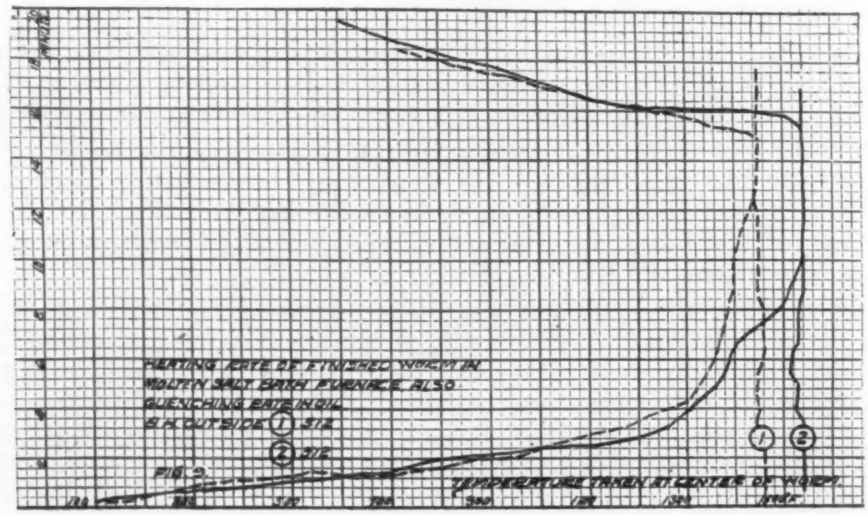


Figure No. 9

Sodium Carbonate, 37½% Sodium Cyanide and 12½% of Sodium Chloride, which makes a convenient, cheap and clean bath for hardening gears. The effect of the cyanide in this proportion on parts of this size, and for the times shown is negligible as far as any case hardening is concerned. You will note the greater rate of heating to 1540 deg. as compared to 1470 deg. F. again.

These curves were obtained in a similar manner to those shown before and showing incidentally the rapidity of cooling this section in an oil at 70 deg. F. of about 100 Viscosity (Saybolt at 100 deg. F.). Also the Brinell hardness taken at the outside of the threads is in each case 512. The oil we use for quenching is a mixture of 70 vis. paraffin and 180 vis. Red Oil, the blend having a flash point of 310-330 deg. F.

If we examine a worm hardened at 1540 deg. F. for even 10 to 11 minutes we find the hardness at the center to be about 500 Brinell, but if we examine the center of a worm hardened at 1540 deg. and then reharden again at 1540 deg. F. for 7 minutes, we find it to be about 340 Brinell and the curve obtained by a transverse test of such a worm shows greater ductility than the one hardened clear through (see figure 10). This, as can readily be seen, represents far better physical properties than either a case hardened worm or a worm hardened through, figures 2 and 3.

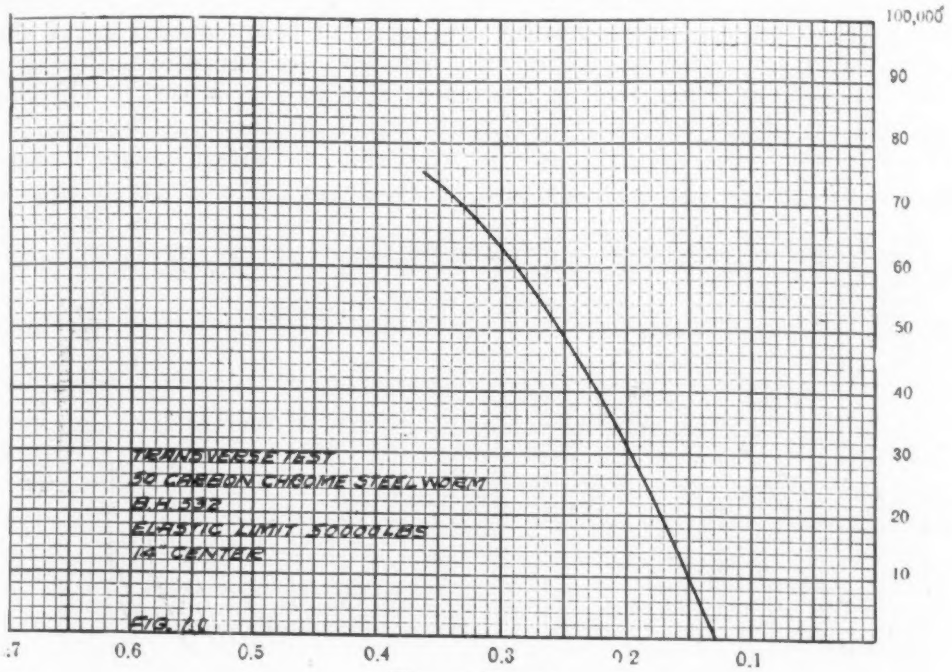


Figure No. 10

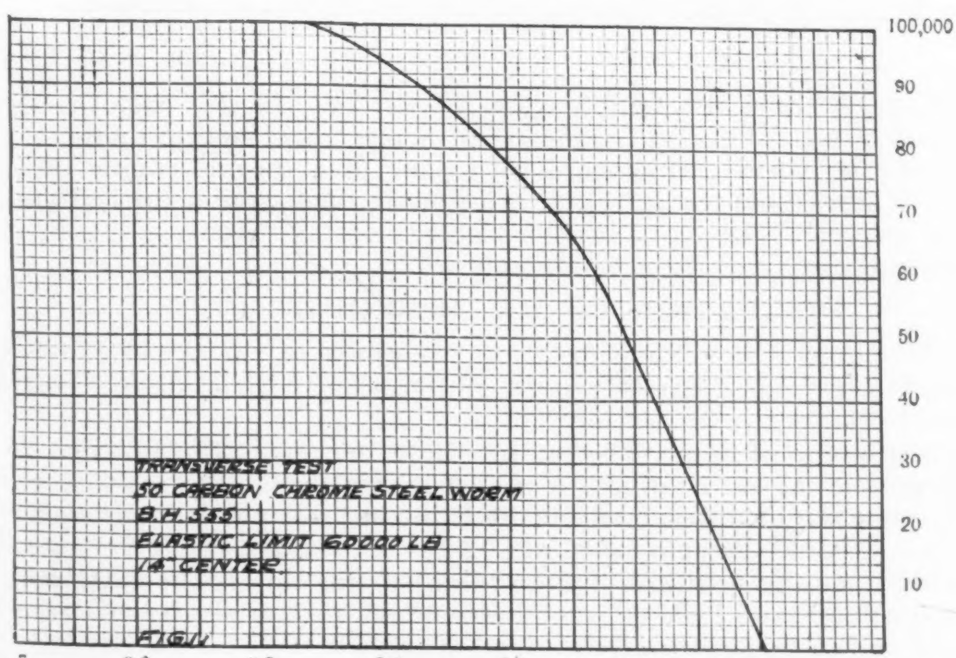


Figure No. 11

This heating time, however, is extremely low and makes handling of the pieces rather difficult, so the curve shown as a dashed line was run with a furnace temperature of 1470 deg. F., and in order to obtain the same temperature at the center of the worm using these conditions, it is necessary to allow the piece to remain in the bath 12 minutes. This temperature, as you will note, gives us the same hardness on the outside as the other, but the center of the worm is not brought up to a hardening heat. An inspection of this worm shows a Brinell of about 340 at the center and 500 throughout the tooth section.

So by treating the worm at the required temperature to harden it all the way through and rehardening it at a lower temperature for a shorter time we obtain a worm in which the hardness throughout the teeth is over 500 Brinell and the core or center of the worm is about 340 Brinell. This gives us a worm whose stress strain curve is shown in figure 11.

The effect of other heating media than the two cited before is brought out by curves fig 12. This shows the heating time of a worm heated in an

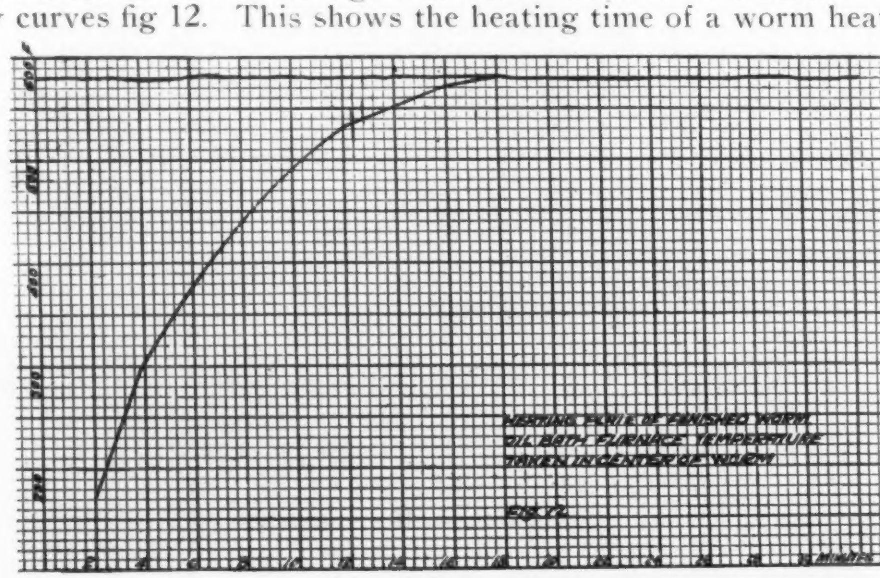


Figure No. 12

oil bath maintained at a temperature 580 deg. F. In this case the furnace temperature was obtained by means of a mercural thermo-meter and the center of the worm temperature by means of a thermo-couple described before. These show the advantages to be derived from a critical study of thermal curves. The work involves no particular extensive layout of apparatus and proves of inestimable value.

DISCUSSION OF MR. McCLOUD'S PAPER

Mr. McCloud: Mr. Chairman and Members of the American Society for Steel Treating—(Reads report, illustrating with slides). Interjects following remarks:

Another point of some interest on these curves is the position of the thermo-couple lag on cooling. You see it is very plainly marked in both curves, some slight differences on the tube, but not particularly bad. The temperature in the one case is about 1240. The slides aren't very good, so you cannot see the position of the ordinates, but this is the 1200 line, and that is the 1300 line, 1300 degrees Fahrenheit, so you see in this case it is 1240 and and in this case possibly 1250 degrees.

Figure 2 is a chart of the stress strain diagram obtained on an Olsen

Testing Machine of a finished tractor worm tested on 14" centers, transverse stress. The curve goes up and the elastic limit is just beyond the 40,000 pound mark. It runs up to this point, and from that point right straight on until failure occurred a little ways over.

That last curve was on a piece of .20 carbon chrome vanadium steel worm case hardened, about 1/32-inch deep.

This curve is that of a high carbon, that is, a .50 carbon, chrome steel, and hardened all the way through. The brinnel is about 500 in the center, as well as on the outside. You will note that the elastic limit, of course, practically coincides with the ultimate point up here at seventy thousand pounds. To be sure, it is nearly double that of a case hardened worm, but its deformation beyond the elastic limit was nil. In other words, it broke right off short.

Figure 5 shows the heating time to this point. This shows the beginning of the curve.

Figure 6. The next curve shows the heating time of a worm in an air furnace at 1600° F. In this case the heating time is 36 minutes, whereas in the other case it was 40 minutes. I had plotted on here the furnace temperature as well as the temperature of the center of the worm. The right hand curve shows the temperature of the furnace taken with a platinum-rhodium thermo-couple, and an Englehardt Milli-voltmeter. The lower line shows the temperature in the center of the worms, finished worms, in these cases, taken with a similar couple and a Leeds & Northrup potentiometer.

I just want to call attention to the difference in the heating time of the finished worm when the furnace temperature was maintained in one case to 1540, and in the other case to 1600. When the furnace temperature was just sixty degrees higher there was a difference in the heating time of four minutes. In both furnaces or both cases the furnace is at substantially the temperature the worms finally attained.

Figure 7. These lines here indicate the furnace temperature, and the other lines indicate the temperature in the center of the worm. I will point out that according to these curves the statement by Wagner, as I cited before, requires modification in certain instances.

We had to start out with a furnace temperature of considerably above 1600, because the heat stored in the furnace walls was not large. It was a laboratory furnace. The dark line shows the heating time with a furnace temperature of 1540 and the other line shows the heating time with a temperature of 1300 degrees.

The time required to bring the center of the forging to the temperature of 1200° F. is less when the furnace temperature is 1600 than it is when the furnace temperature is 1550° F.

In these cases you note the A. C. point is quite clearly defined as being 1350 degrees. Incidentally, that is about 100 degrees lower than that determined on a small piece by a differential method. I presume the difference was probably due to the mass, and I would explain it as representing the average critical point of the steel. In other words, the temperature of the outside was probably above the critical point.

Figure 8. This is just a differential curve, a critical point curve, taken on a piece of material of this analysis, showing the critical point on heating of 1420 to start, and an average of 1450, and on cooling a maximum difference in temperature of the nickel body and steel piece at 1280 degrees. These curves were taken in a molten salt bath furnace.

Figure 9. You will note in this case the curve with the solid line is the heating time for a worm, for the center of a finished worm, when the furnace temperature was maintained at 1540 degrees. You will see the furnace temperature is right along that line, and the other is for a furnace temperature of 1450 degrees. You will note that the worm when the furnace temperature is 1540 gets up to the heat of the furnace much faster than it does when the temperature is actually lower—at 1470.

These curves were taken in a similar manner to the ones before and, incidentally, show the rapidity of cooling of the worm in oil. We use the oil at a temperature of about 70° F., an oil of 100 viscosity, and it is a mixture of paraffin and oil having a flash point of 310 to 330° F. Also the brinnel hardness taken on the outside is, as indicated, 512 in both cases.

Figure 10. This is a transverse test of a worm and shows an elastic limit of around sixty thousand, and an ultimate strength of one hundred thousand, and a deflection of about .4 of an inch. In this particular curve the worm did not break. Our testing machine is only a one hundred thousand pound machine, and we find a great number of worms that we are unable to break.

Finishes paper and discussion. (Applause.)

Chairman: I know we have all listened with much interest to this question of the time and temperature, etc. There is no question but what there is considerable to be learned by studying these conditions and, of course, we can see their value, not only from the quality standpoint, but also from the production standpoint, which presumably, in most shops today, is a point of great importance.

Mr. Stagg: May I inquire from Mr. McCloud if the material on which he obtained his heating curves when he was working in production and material and the material that he obtained his heating curves from when he was working experimentally with the differential were one and the same lot or part of the same material. I am unable to reconcile a difference of 100 degrees in a critical temperature on the same material, under production methods and under experimental methods.

Mr. McCloud: It was not the same piece. It was a piece of the same material, it had the same chemical analysis, but was not the identical piece.

Mr. Stagg: May I ask you how you explain the difference?

Mr. McCloud: It is, as I attempted to explain it, I would say that the difference in the lag was due to the fact that in the case of the large piece we actually took the temperature of the center of the worm, whereas in the small piece you take substantially the temperature of the whole piece, and in the case of stock heated as rapidly as that was heated, the outside was at critical point considerably higher, and the mass of the steel, which determines the lag anyway, was considerably above the temperature of the center of the piece.

Mr. Stagg: I assumed that was going to be your explanation, but I wanted to be sure to bring out the salient point that the critical temperature is a constant in any material.

Mr. McCloud: Oh, yes, that is so.

Mr. Marshall: In my experience I have actually forced the critical range higher than it should be, and I can explain it in this way. The work was only touching the couple, and the couple caused a reaction from the reading temperature of the couple. In that way the temperature will get ahead of the temperature of the piece. I have seen a plain carbon steel with a critical range of 1375 occur as high as 1425.

Mr. Stagg: Which is the very converse of Mr. McCloud's statement. He was testing from the center of the piece and you were testing from the outside.

Mr. Hodge: I would like to ask if failures were frequent, and if so, what was the matter, that is, would the worm break transversely or the surface fail?

Mr. McCloud: The largest component of load in the case of a worm is transverse component. If you analyze the stresses on a worm you will find that while there are several applications of stress, the stress which brings the greatest fiber strain on the material is the transverse load, and in the case of worms that are hardened clear through we had instances of failures, and the failures were all transverse fractures. Sometimes we would have a little trouble with the surface of the worm in grinding on account of carbonizing a worm, but that has been the only surface trouble that we have run into. You see, the tendency is always to push the grinding a little bit too hard, and if trouble starts in the case, of course it is made worse during the use of it.

Mr. Hodge: What I was trying to bring out particularly is as to carbonizing the worm. That is, a carbonized worm, leading to the core, would never fail under transverse load, or would never break, if properly heat treated. I imagine the trouble in that case would be in throwing out of line and poor measurement. I wondered if that actually occurred.

Mr. McCloud: I don't recall any cases of failure or carbonized worms other than surface troubles that I spoke of before, and I personally believe that all that trouble was traceable to the condition of the material as it was ground or right after it was ground. One of the biggest factors that decided us to attempt oil-hardened stock was the saving we believed we could effect in production.

Mr. Marshall: I would like to ask if there were any deleterious effects noticed due to introducing the steel into a hot furnace.

Mr. McCloud: I can't say I have ever seen any that I would explain in that way.

Mr. Marshall: No effect on the outside surface of the worm?

Mr. McCloud: No.

Member: I would like to ask Mr. McCloud if he noticed any difference in the time of heating with the difference in fuels used in the furnace at the same temperature.

Mr. McCloud: I cannot say as I have, and it hardly seems to me, offhand, that you would note any difference under conditions such as I cited. Of course, I refer the most particularly to that curve that showed the heating time in the molten salt bath furnace. The method of heating is by conduction from the bath of salt, and maintaining the furnace at a given temperature, I can scarcely see how you could affect at all the heating rate, through using different fuels.

Member: For several years we have noticed a difference in time of heating with the different fuels at the same temperature, but nothing definite has been hit upon by men of your ability or your opportunities in those directions, and it is just in that connection that in some heat-treating plants where they have used an oil fuel and have changed to a gaseous fuel that the time of heating has been very materially decreased, and with the same temperature of the furnace.

Mr. McCloud: I might explain a little bit better what I mean by that. The curves taken in a molten salt bath furnace were taken of a single worm put in a cyanide box about sixteen inches in diameter and about the same in depth, and the curves showed that the drop in temperature of the furnace was negligible when the piece was put in, and the curves that showed the heating time in the electric muffle, which was not particularly large, and a forging that size took up a great deal of the heat of the walls of the furnace, consequently, under such conditions as that, probably the heating time would be affected by the fuel used, but where you use a molten salt bath furnace under the conditions that we give it, the drop in temperature would be negligible.

DISCUSSION OF MR. T. D. LYNCH'S PAPER

Article Published in October, Page 62, Vol. 1, No. 1.

Chairman: I am sure it is with a great deal of interest that we have listened to this very excellent paper by Mr. Lynch. As he began reading certain clauses of the specifications, it took me back to the busy days of two or three years ago when all of us were either busy preparing certain specifications or being told how absurd certain things that we prepared were. The things that I wondered regarding the specifications which he has prepared are whether or not these specifications have been submitted to a steel mill, and if so, if they are thoroughly in accord with them and are willing to cooperate and produce material in accordance with them.

Mr. Stagg: Regarding the request of the professor as to whether a steel mill will meet these specifications, I am not quite sure, but I wouldn't be a bit surprised if Mr. Lynch didn't have to visit some steel mill and see their practice and incorporate their practice in his specifications.

Mr. Cook (member): Mr. Lynch pointed out that the engineer and the metallurgist and others should coordinate. I think he really forgot the cost department. I was just wondering how much he would have to pay per pound to meet such specifications.

On the other hand, I think it is certainly very well put together, and the only possible flaw to make it thoroughly complete would be the point of heating up the ingots. In silicon steels such as he mentioned he said the silicon should be about two per cent. One very important point is the rate of heating up of the ingots before they are rolled. That is one of the principal causes in bringing about flaws and defects in high silicon steels.

Mr. McCloud: I have been interested in specifications on a somewhat smaller sized spring that requires a great deal of care. I should like to ask Mr. Lynch an expression of opinion as to whether or not it is advisable to incorporate in the specifications the closing pressure to some pre-determined height as well as the free height of the spring, or whether either one or both of them should be included. I don't know whether you understand me or not, but, supposing the spring is not stressed, it is designed so it will not be stressed beyond its elastic limit. It would be possible really to produce, to specify a spring either according to its pressure at a given height or according to its free height, specifying the size of the wire, for instance, or whether it is advisable to put in both.

Mr. Lynch: The question of the design of springs is one that is a very large one and it has been, I should say, dependent very much on the use

you are going to put the springs to, as to what sort of tests you are going to put them to. In this particular picture or application, his application is run so it is perhaps necessary for the spring to become closed on certain conditions, because it cannot go its limit, whereas other springs would not be limited; they can be compressed beyond their elastic limit, and not be in an entirely enclosed position. As far as the other question is concerned about the material, this has been made, and the steel makers and spring makers have been very courteous in working out these problems, and we have a good many of those springs in service. The paper was not read so much to bring out the point of the application as it is to bring out the application of springs in severe service in various places, because the locomotive people are having a great deal of trouble with springs breaking in service, and they want a higher quality of spring, even at very much increased cost. The first cost of a spring is not always the whole story, because, if a spring breaks, it costs so much to put the locomotive out of commission and until a new spring is obtained, so the first cost is not the whole cost, and the whole cost, if it is the entire cost, brings it down to a proportional proposition.

Mr. Birkbeck: You spoke about 150 points of silicon. Do you think that is good policy?

Mr. Lynch: I think we want uniformity; we want to know what we have. We might be able to work it out at 150; 220 is the standard recognized by steel makers. I would like to state in this connection that in working out specifications we have always found it very desirable to take as nearly what is already commercial and embody that rather than to attempt to get up something that is new, that is, so we do coordinate with the steel makers, and use their mill practice just as closely as we can, and the fellows that don't line up and give us good uniform results—train them and get them to the point where they will line up and give us those results. In this case the spring manufacturers are lining up.

Mr. Kaufmann: I want to ask you why you limit specifications only to crucible and electric processes.

Mr. Lynch: There is another case where we want the best product we can get, and we have every reason to believe we can get a more uniform product either in the crucible or the electric furnace than we do in the open hearth, especially in the large open hearth heater. The people that are manufacturing open hearth steel as a rule don't take the same care in the manufacturing of the steel as the man who makes it in smaller quantities in the crucible or in the electric furnace. It is quality we are after, rather than quantity.

Mr. Johnson: I would like to ask Mr. Lynch what are the best tensile figures he has found so far on his silicon-manganese steel. Those that he would consider the most ideal thus far.

Mr. Lynch: Mr. Chairman, we would like the tensile to run 200,000 pounds or better, and I have not gone into that end of it so thoroughly as I would like to. I shouldn't wonder if Mr. Stagg couldn't enlighten us on that, because he has been kind enough to help treat some of this product. He has helped me a great deal in working out this problem. We have been checking very closely on the brinnel tests rather than on the physical or full tensile tests.

Mr. Stanger: I would like to ask a question. I have never been able to satisfy my own mind what the answer is. It is in reference to silico-

manganese steel. If we take silico-manganese steel made by the electric furnace and made by the open hearth process and the steel has the same composition, give it the same quenching temperature and the same quenching medium, we find that we get equal brinnel hardness, but we have to draw the open hearth steel about one hundred degrees Fahrenheit higher than we do the silico-manganese steel that is made by the electric furnace. I would like to have an answer to that if anyone here can give it; I have never been able to satisfy myself as to this difference and the reason for it.

Prof. Harder: I would like to inquire of the author if he tried to get sufficient hardness working at somewhat lower temperature, 850 to 875, and if he was not able to get it with the lower temperature, what type of oil he uses, especially with regard to classification as a heavy oil or a light oil.

Mr. Stanger: We used a light oil, comparatively speaking. As far as that is concerned, the quenching speed of oils on some tests we made a year ago would indicate it doesn't make very much difference.

HEAT FLOW THROUGH FURNACE WALLS

E. F. Davis.*

A paper presented at Philadelphia Convention.

PART II. (Conclusion)

Assume that you have a heat-treating furnace to build and that you wish to make the walls 13½″ thick and temperature of 1600° F., the room temperature is 70° F. What advantage would there be over a furnace wall composed of 13½″ of firebrick by one of the same thickness consisting of 9″ of firebrick and 4½″ of Sil-O-Cel.

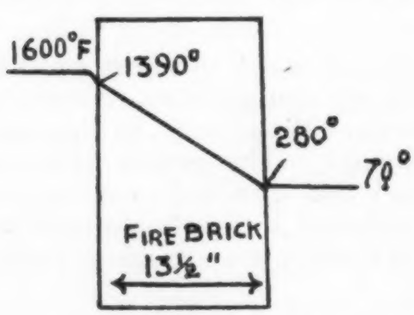


Fig. 1

Air Temp. Diff.—1600—70=1530° F.

Average internal conductivity of firebrick at 1600—70=835°. Mean temperature equals, according to B. Dudley, Jr., tests at Pennsylvania State College 7.9 B. T. U. per square foot per hour per 1″ thick for 13½″, the heat flow would be

$$\frac{7.9}{13.5} = 0.5852 \text{ B.T.U. per deg. temp. diff.}$$

This difference must be: $\frac{755.35}{0.5852} = 1290.8$ deg., which deducted from 1530 deg. leaves 239.2 deg. for temperature drops at the two faces, or 119.6 deg. on each surface. The required heat emission factor would, therefore, have to be

$$\frac{755.35}{117.6} = 6.32 \text{ B.T.U.}$$

*Sales Engineer, Celite Products Co.

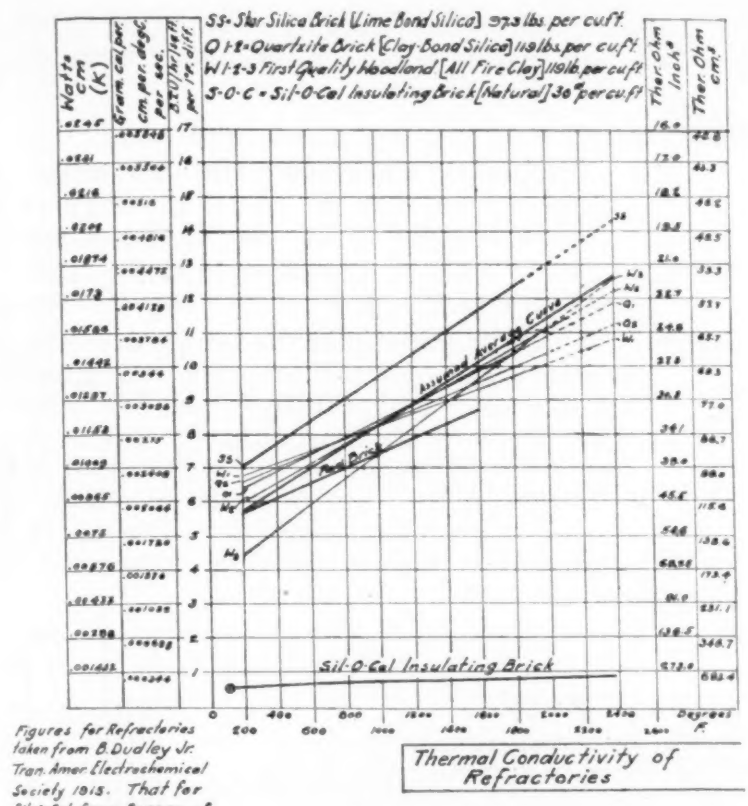


Fig. No. 5

In reality the emission factor at this difference cannot exceed 2.2 B. T.U. Therefore the temperature drops at the surfaces must be more than 119.6 degrees, and the surface temperature difference less than 1290 degrees and the whole heat less than .753 B.T.U. per hour.

After a number of trials of such temperature drops are obtained as satisfy the various known relations, factors of heat emission at the various surface temperature differences being derived from L. B. McWilliams' test of pipe coverings (*A. S. M. E. Journal,* Jan., 1916) and *Power,* April 9, 1916. Assuming constant conditions, the rate of receiving, transmitting and emitting heat from a square foot of wall per hour is as follows.

At hot side........	210 deg. × 3.093	649.5 B.T.U.
Through wall......	1,110 deg. × 0.5852	649.5 B.T.U.
At cool side........	210 deg. × 3.093	640.5 B.T.U.
Total..........	1,530 deg. air temp. diff.	

The heat loss per square foot per 10 hours under the conditions stated is, therefore, 6495 B.T.U. not 7554 B.T.U. The ratio is as 86 to 100.

A more accurate determination of the true heat loss is somewhat tedious, because the heat conductivities vary with the mean temperature which are not known. In addition, the total heat flow is governed by the surface temperatures, which also are not given. In the absence of charts the results must be found by successive approximations.

Assuming the internal conductivities of the wall to be—

$$H = \frac{1}{\frac{9}{9.4} \quad \frac{4.5}{.65}} = .127 \text{ B.T.U. per degree.}$$

The rates of heat flow per square foot per hour are found to be:

At hot side.............	86 deg. × 2.0	— 172 B.T.U.
Through wall...........	1,358 deg. × .127	— 172 B.T.U.
At cool side............	86 deg. × 2.0	— 172 B.T.U.

1358° is found by referring to Fig. 2, which shows a drop for inside

and outside of surface to be 1258°. The 86° is found by subtracting 1358 for (1600 — 70) which equals 172, half of this is 86° or the temperature drop on each surface.

Fig. shows the temperature gradients by this method.

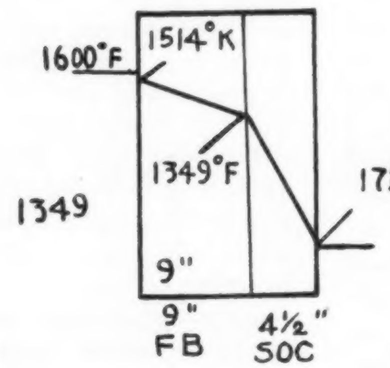


Fig. 2

Temperature gradients through wall.

1600° — (172 × 1/2 = 86) = 1514°
1514° — (172 × 9/9.4 = 165) = 1349°
1349° — (172 × 4.5/.65 = 1193) = 156°
156° — (172 × 1/2 = 86) = 70°

It will be noted that the temperature drop per inch through the firebrick was approximately 24° and through the SOC 265°. This amounts to approximately ten to one, but it is the belief of the writer that this is rather high. Six or seven to one being nearer correct in practice. The method shown in this calculation, however, is correct.

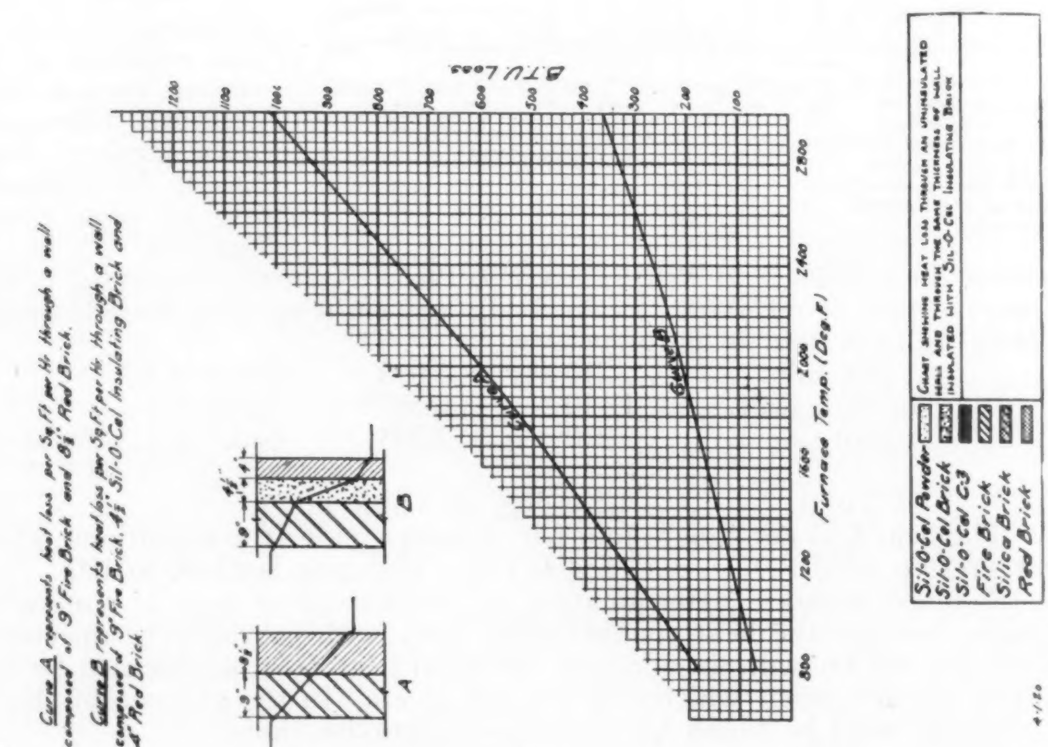


Fig. 5

Advantages of Insulation

The advantages accruing through the right method and character of insulation are many. Considering again furnace walls as a matter of illustration, the accompanying diagram (Fig. 1) sets forth conventional insulated and uninsulated walls, giving a typical example of the effect of insulation when applied to the wall of the heated equipment and regardless of the exact nature of that equipment.

Taking an internal temperature of 1600° F., and a surrounding atmospheric temperature of 70°, the exterior uninsulated wall shows a temper-

ature of 280° as against 156°, with an insulated wall. The insulated walls, as will be noted, consist of 9" of firebrick, 4½" of insulating brick; while the uninsulated walls are composed of 13½" of firebrick.

The resulting fuel saving is also shown in the figure, based on 1,000 square feet per hour of radiating surfaces, and utilizing coal, oil and gas, respectively, as fuel. It is found that the insulated walls saves 38 lbs. of coal, 3.1 gals. of oil, or 757 cu. ft. of gas per 1,000 sq. ft. per hour radiating surface, in accordance with the different character of fuel. And further, it is interesting to note that the B.T.U. saving amounts to approximately 70% of the heat lost through the uninsulated walls.

This is but an ordinary example of what can be accomplished with proper insulation. It illustrates in a striking manner just what is going on with uninsulated equipment in the heat-treating plants; it points out a comparison of losses and shows, generally speaking, how such losses can be corrected. This heat, so lost ordinarily, should be put to productive use, and in putting this heat to work lies the greatest benefit of insulation, for it enables us to speed up production without increasing equipment, and hence lowers production cost through a decreased overhead.

Insulation of a Large Annealing Furnace

The following is the method used in the insulation of an annealing furnace:

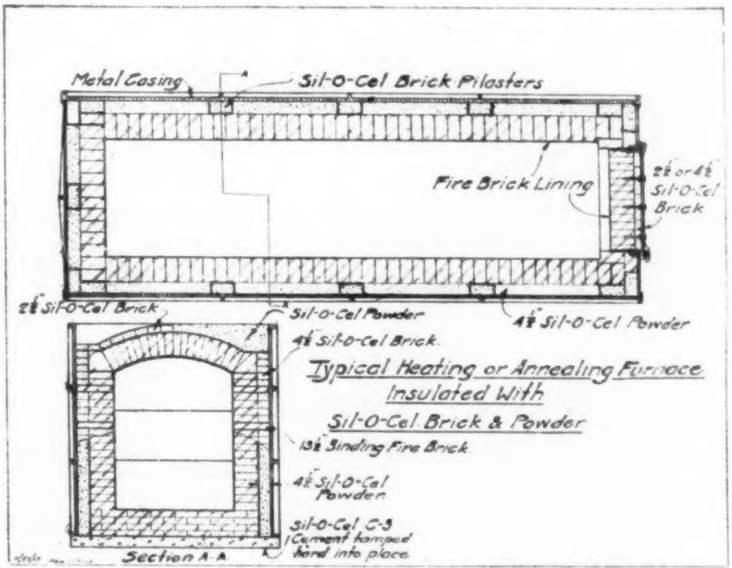


Fig. 6-A

Below the floor line, between the flues, the ground is well tamped and there are two courses of three-inch tiles with broken joints layed down as a foundation. Over this is one inch of grogg. On top of this two and one-half inches of Sil-O-Cel brick. Over the Sil-O-Cel brick from three-fourths to one inch of grogg, and on top of this or on what is called the furnace floor, are three inches of vitrified firebrick flooring.

The side wall construction is very rigid and substantial. It consists of cast iron channels with the flanges drawn in. The channel is approximately one inch thick. The flanges are about four inches. A course of red brick to a thickness of four and one-half inches is layed up against the channels, which is supported from the outside by very strong stays. Next to the red brick are four and one-half inches of Sil-O-Cel brick and then

9 inches of best No. 1 firebrick obtainable. The firebrick and redbrick are bonded through the Sil-O-Cel brick at intervals of three or four bricks, every fifth course staggered.

They want rigid construction, as the side walls carry the arch, which contains Sil-O-Cel brick. The rear wall is being insulated the same as the side walls. The furnaces are fed from the rear. There are two doors, in cast iron form, to each furnace, size approximately six feet wide, nine feet high and approximately nine inches thick. The furnace is approximately 12 ft. by 12 ft.

The arch, inside dimensions, has a radius of 11 feet, while the outer dimensions are eight feet six. The doors are removed by an electric crane operating over the furnace. Just now the doors contain 9 inches of firebrick, but in the future will have C3. The temperature here never exceds 1800° F.

Insulation of Rotary Type Furnace Carbonizing

One of the largest manufacturers of gears has recently had installed and put into successful operation a furnace for carburizing that should be of interest to all users of heat-treating equipment. This furnace was designed and erected by Tate-Jones & Co., Inc., Pittsburgh.

Although the principle has been incorporated in a few furnaces now in operation, the design of this furnace is new and original, and is of the Rotary or Rotating Hearth Type, as shown in Fig. 7. Oil is the fuel used.

The general shape of the furnace is shown. The revolving carriage or hearth is 16 ft. 6 in. outside diameter and 6 ft. 6 in. inside, having a width of 5 ft. 0 in. and revolves on wheels set in the foundation. The furnace is 19 ft. 0 in. over all, and is insulated as follows:

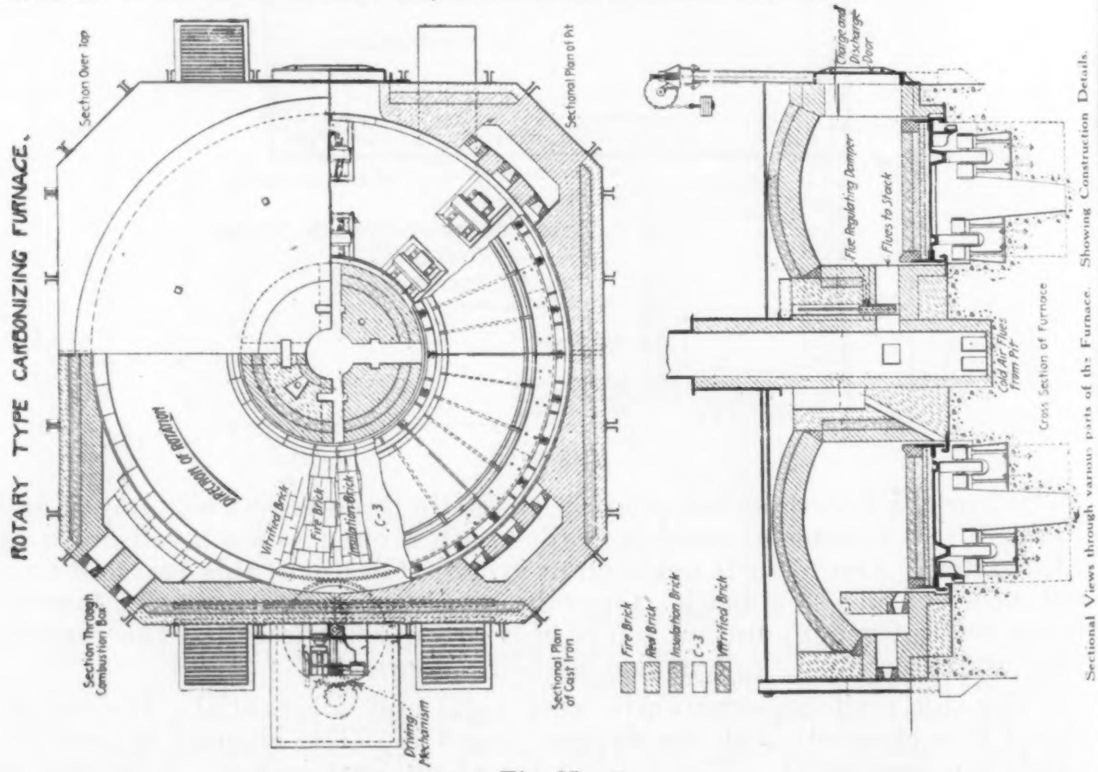


Fig. No. 7

The top of the furnace is insulated with Sil-O-Cel.

The side walls are insulated with $4\frac{1}{2}$ in. Sil-O-Cel brick.

Burners at the four corners fire into combustion chambers and the heat is led from these so as to be evenly distributed over the hearth, and finally is vented to the center and is carried out of the building by a stack.

Power to drive the hearth is derived from an electric motor which is geared down so that the hearth makes one revolution in the time required for carburizing. This gearing is so devised that the time of revolution can be regulated varying from 6 to 12 hours in steps of 15 minutes.

The sand seal around the edge of the revolving carriage was removed and Sil-O-Cel C-3 powder substituted because the sand offered too much friction and conducted the heat away.

The hearth is insulated with 4-in. Sil-O-Cel C-3 and temperatures around the running gear have not exceeded 300° F., even after weeks of continuous operation.

The saving over a similar furnace not insulated is 20% of the fuel.

Methods of Insulation by Various Furnace Manufacturers

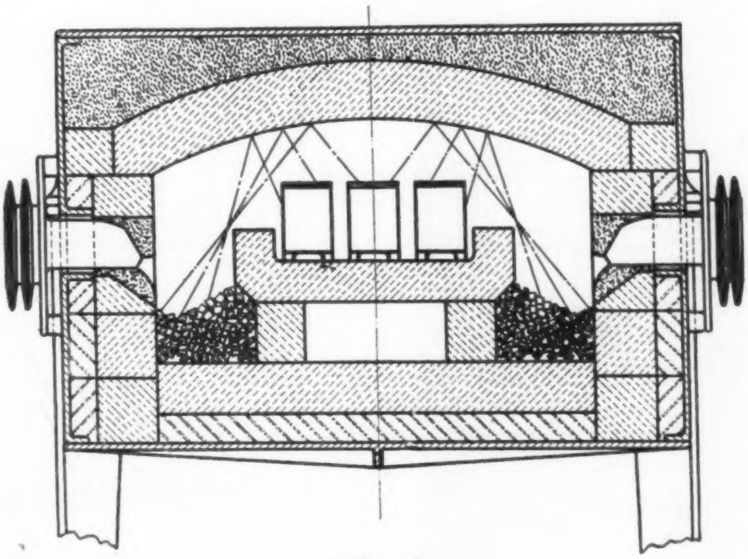


Fig. 8

Fig. 8 shows method used by the Surface Combustion Company to insulate their heat-treating furnaces. Sil-O-Cel powder is placed in the upper part of the furnace over the firebrick arch and standard Sil-O-Cel split

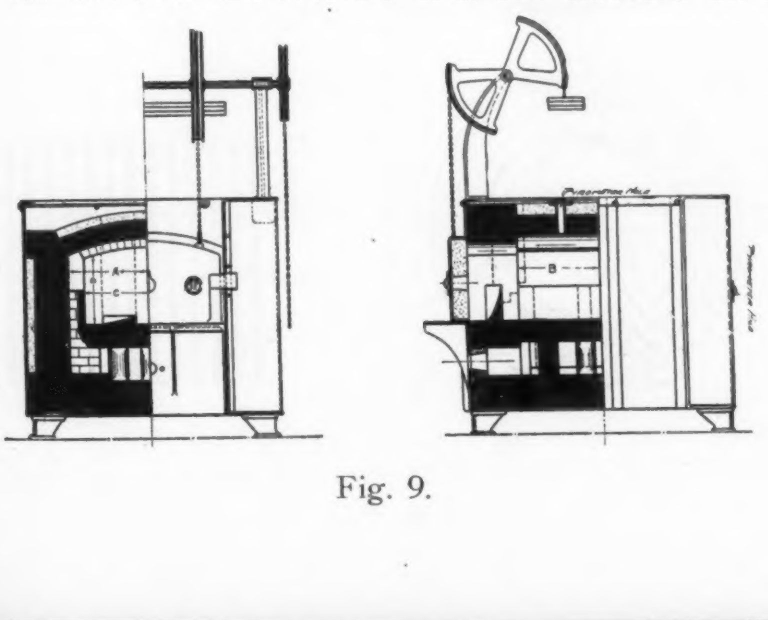


Fig. 9.

$9 \times 4\frac{1}{2} \times 1\frac{1}{2}$ and placed in the side walls and bottom of the furnace next to the outer shell or casting.

Fig. 9 shows a car type furnace made by the Tate Jones Company and the method in which they use Sil-O-Cel for insulation. Two and one-half-inch Sil-O-Cel brick is used over the arch, 4 in. of C-3 or calcined.

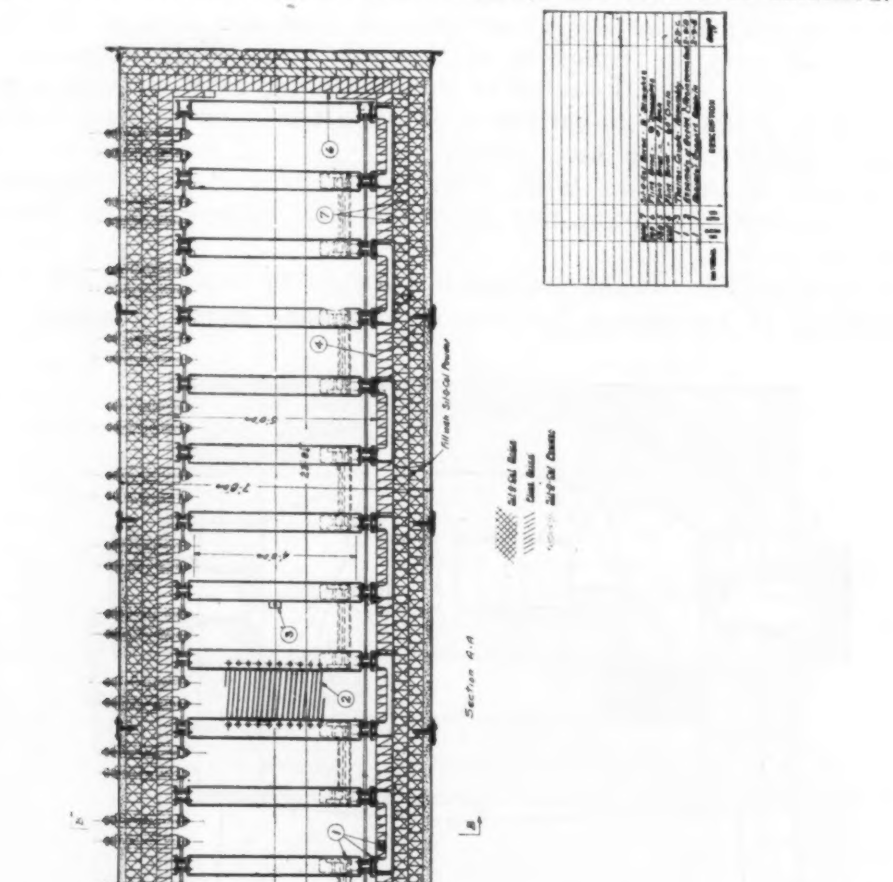


Fig. 10

Sil-O-Cel under the firebrick hearth in the car. A minimum of 4 in. of C-3 is used in all their doors.

Fig. 10 shows the method used by the American Metallurgical Corporation to insulate their electric furnaces. The above photo shows that the construction of this furnace is as follows: 4½ in. of firebrick, 9 in. of C-22 calcined Sil-O-Cel brick and 2 in. of Sil-O-Cel powder rammed between the brick and the outer shell.

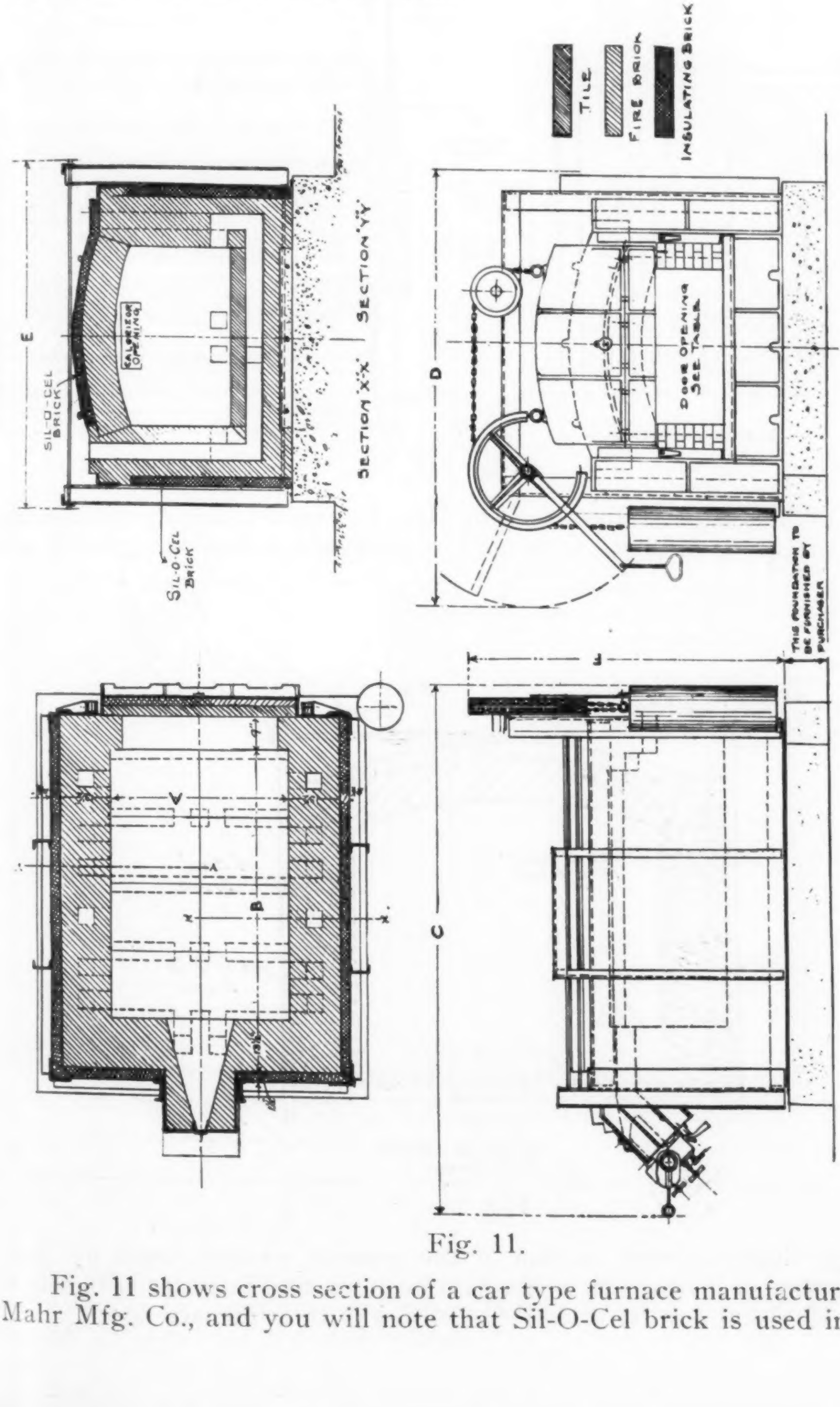


Fig. 11.

Fig. 11 shows cross section of a car type furnace manufactured by the Mahr Mfg. Co., and you will note that Sil-O-Cel brick is used in the side

walls and over the arch of these furnaces, 2½ in. thick. On the car under the firebrick part 2½ in. of Sil-O-Cel C-3 is used. In the doors a course of Sil-O-Cel brick 2½ in. thick is layed back of the firebrick, which prevents loss through radiation, which is always a big item in heat-treating furnaces.

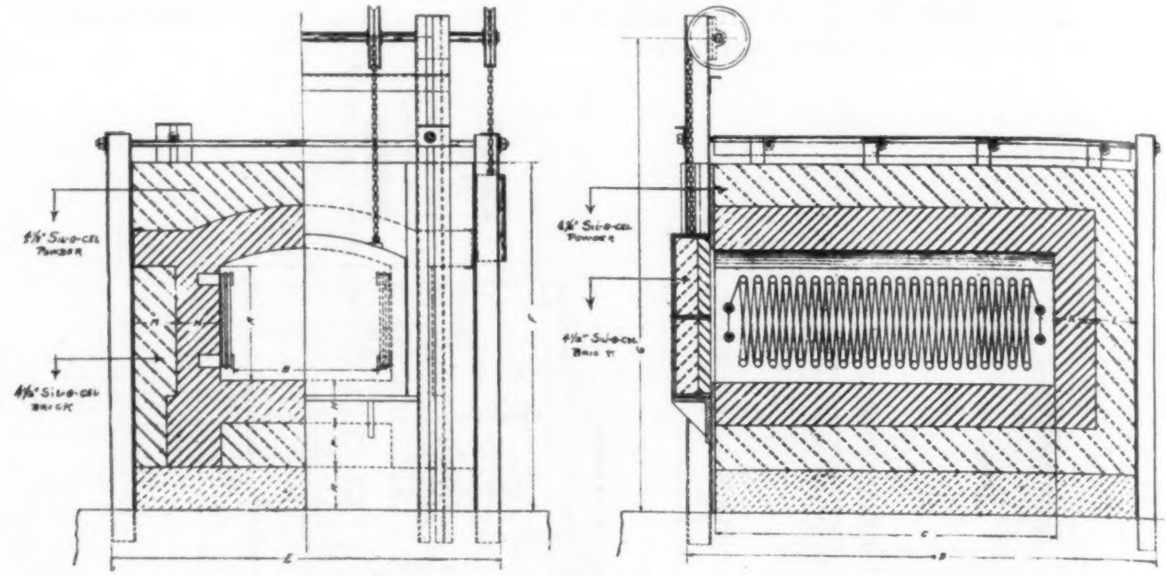


Fig. 13.

Fig. 13 shows the method used by Geo. J. Hagan Company to insulate their heat-treating furnaces with Sil-O-Cel standard insulating brick and powder.

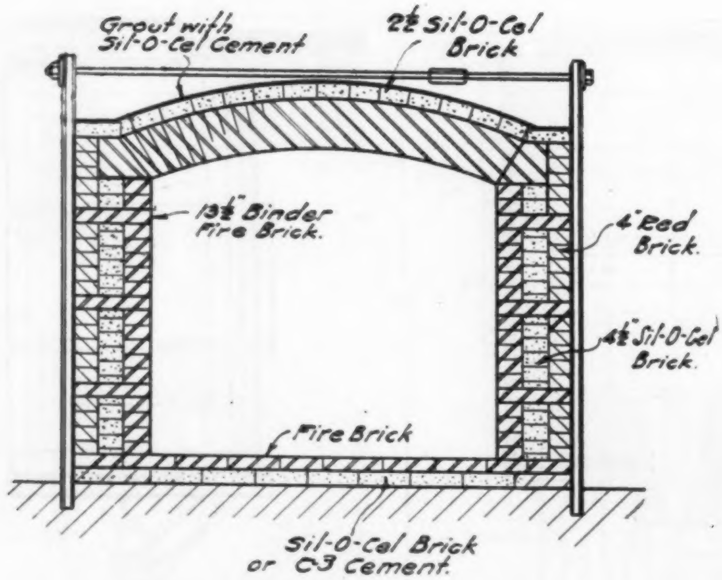


Fig. 14.

Fig. 14 shows a cross section of the general methods used by Tate Jones Company to insulate their standard heat-treating furnaces with Sil-O-Cel brick, Sil-O-Cel powder and Sil-O-Cel C-3 in their furnace doors.

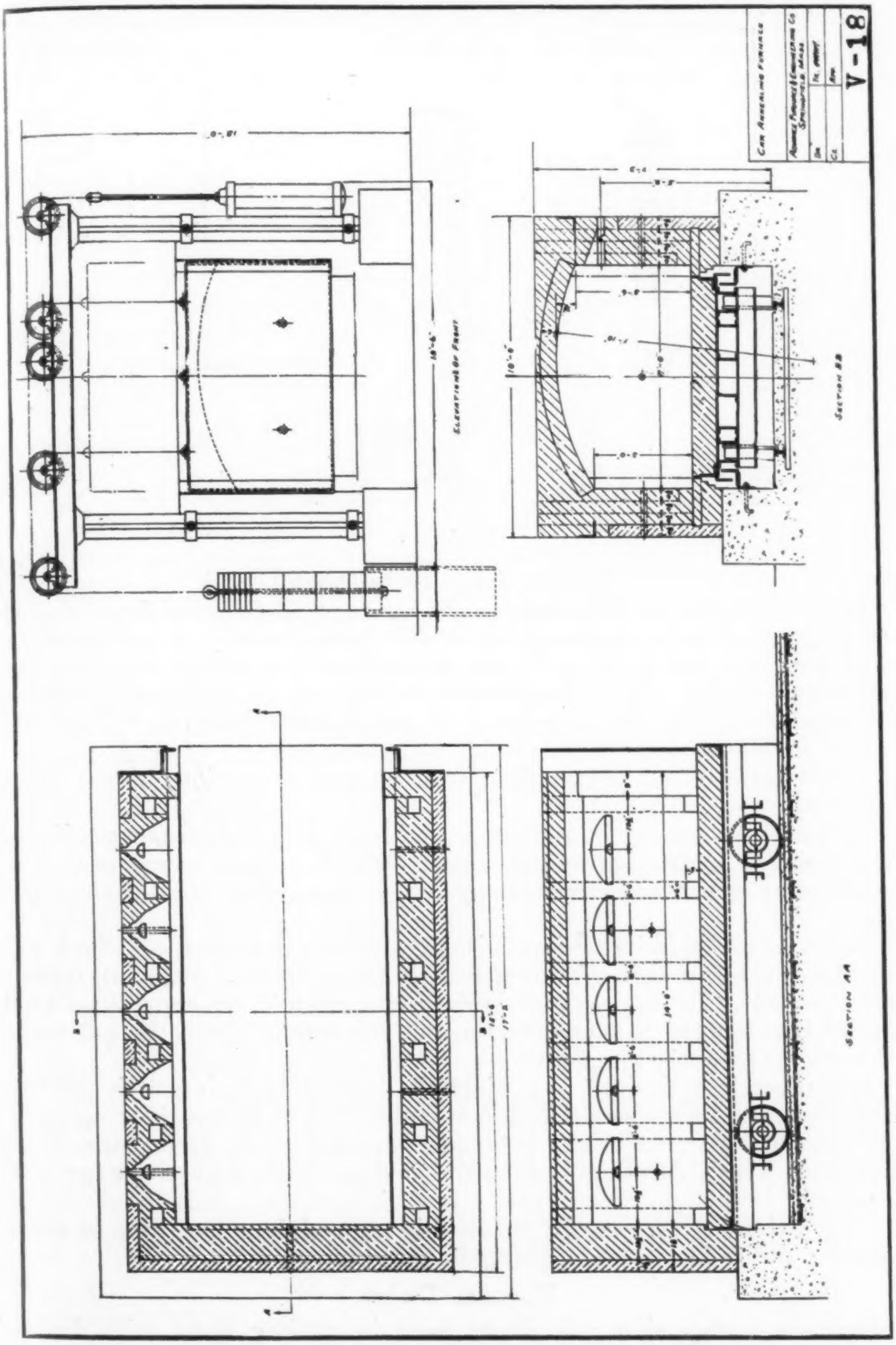


Fig. 16.

Fig. 16 shows a cross section of an electric heat-treating furnace made by the American Metallurgical Corp. This cut shows the use of the C-33 calcined Sil-O-Cel for the middle wall.

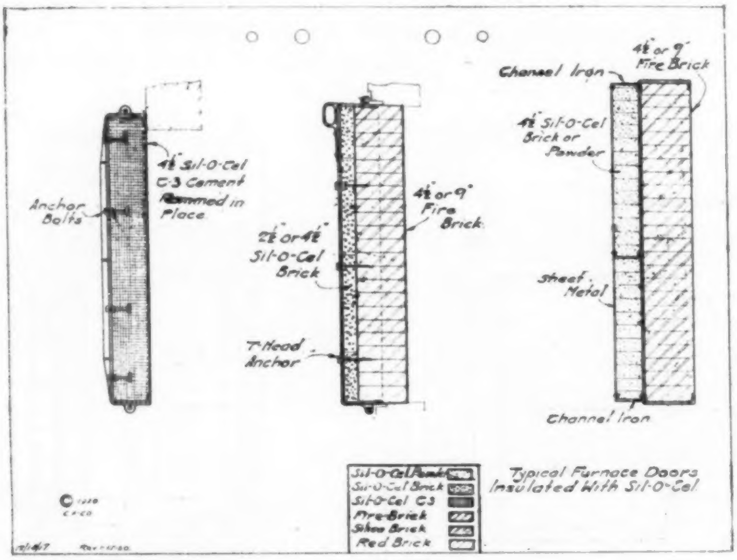


Fig. 17.

Showing use of C-3 in Furnace Doors

Comparative tests have been made between Sil-O-Cel C-3 and firebrick as to the cost of labor and material and it has been shown in a number of cases that Sil-O-Cel is 50 to 75 per cent cheaper to apply, also the life is considerably longer and approximately 50 per cent of the heat lost through the doors when lined with firebrick is saved when Sil-O-Cel C-3 is used as an insulator.

Small furnace doors less than 2 ft. in any dimension do not require reinforcing.

Furnace doors used in annealing and heat-treating furnaces which are larger than 2 ft. in any dimension require tie rods as reinforcements. These tie rods are run vertically and horizontally, placed not greater than 18 in. apart.

In doors of this kind it is advisable that poultry wire of 1-inch mesh be used as a reinforcing. This is generally placed between the intersections of the tie rods. In all instances reinforcing should be kept close to the center of the door, as it keeps the tie rods far enough from the hot surface of the door to avoid expansion.

Wherever it is desired to project the insulating lining, it is advisable to use a course of fire brick on edge completely around the door up against the steel, letting these bricks protrude past the steel, giving the desired projection. The C-3 lining is then finished up flush with the edge of the brick.

Peep holes are very easily put in this type of door by filling in around a core the desired size when filling in the door.

Furnace Doors

Furnace doors, as a rule, have been heretofore lined with firebrick from 2½ in. to 9 in. thick. On doors of this kind the brick must be properly wedged in—this necessitates a great deal of cutting of the firebrick. By laying these doors on the floor, turned up as a mould, they can be easily and quickly filled with Sil-O-Cel C-3 cement, which has previously been mixed with 20% by volume of Portland cement, thus cutting down labor costs.

An Annealing Medium

The annealing operation in general is carried out by heating the products to the required temperature and then cooling them in a pit of convenient size, filled with this powder. Such an annealing bed in service is shown in one of the illustrations. The pit is constructed of firebrick to such depth as required and to a height of about four courses of brick above the floor line. The annealing pit is directly opposite the furnaces, with a traveling crane available for conveying heavy parts from the heating furnaces to the powder bed.

In operation the heated metal product is immersed in a bath of the powder ranging from 6 to 8 in. in depth and deeper, depending upon the size of the casting and the rate at which the cooling is to be effected. After the required cooling point has been reached, the product is removed from the bath and worked in subsequent operations in the usual way. The rate of cooling, as will be understood, is dependent upon the depth of the powder and the construction of the pit. The lightness of the powder permits the heavy metal parts dropped into it to bury themselves rapidly where the bed will allow. To facilitate the handling of small castings and forgings, the powder can be used in small iron pots, boxes or other containers. As in the case of the larger parts, the castings are dropped into the bath after being heated in the furnace and allowed to cool. The powder is removed readily from the part as it is taken from the pit by simply brushing the surface, making it immediately available for machining or other operation.

This powder can be used indefinitely for annealing work. There are plants today which are utilizing supplies that have been in service for two years or more, with the material changing in color from its original white to a reddish pink. In this, it is stated by users, the powder bed really grows better and more effective in its ability for annealing work as the term of service expands, the moisture in combination being driven off and the resultant dryness enhancing the working value.

Beyond this feature of economy the powder makes for slow and absolute uniformity in cooling, eliminating any cooling strains on the parts annealed, with freedom from hard spots on the product. Moreover, it prevents the formation of any scale blemishes incident to the oxidation of the heated part, and in the case of medium carbon chrome steel parts it bars serious cracking of the material. The use of this powder also eliminates any necessity for reheating the furnace, allowing for continuous use of equipment with conservation of fuel and increased output.

Its Utility for Different Products

To afford a comprehensive idea of the use of Sil-O-Cel powder in various mechanical plants and its service for annealing products of different character, the following is cited: At a large works manufacturing differential gears for automobiles, various gear forgings are annealed, heating the parts to the required temperature and placing in a bed of the powder until cold. Different tools and tool steels are annealed in the same way, utilizing the powder instead of mica dust. For chrome-nickel steel gears this company uses a pit 8 ft. wide, 20 ft. long and 24 in. deep, constructed of firebrick laid so as to give a wall 4½ in. thick. Gears of this type are left in the powder bath from 18 to 24 hours and are then removed thence for the machine operations.

A New England machine tool plant, specializing in the production of automatic screw machines, uses a bed of this powder for treating carbon

and high-speed steel castings. In this the material is heated to the proper temperature in the furnace, under open fire annealing, and buried in the powder. It requires about 24 hours for parts of this nature to cool. Chrome-vanadium steel, intricate parts, clutches and kindred specialties are being handled with great success in these powder pits at this plant.

The annealing, both of iron and steel castings, is being carried on in a Western Iron & Steel Works by the use of this powder. Castings weighing from 30 to 80 lbs. are treated in this way, entirely covered with the material to provide gradual cooling. Parts heated to 1600° Fahr. are cooled in these pits and perfectly annealed. Beds as large as 5 ft. or more are in service, conveniently located so that overhead traveling cranes can drop the heated parts rapidly. Hydrated lime and graphite were used previously at this plant or similar service.

FACTORS LIMITING THE USE OF MATERIALS

Ira T. Hook*

A Paper Presented at Philadelphia Convention.

Introduction: As a military commander of a besieged city seeks to determine the strength of the forces limiting him to the encompassed city, so it is necessary for the engineer to take an occasional survey of the factors limiting him in his applications of forces and materials. With this purpose in mind the writer seeks to point out and summarize these limiting factors for the more common materials of construction.

List of Materials: A fairly complete list of the ordinary materials of construction now in use may be given in seven general groups.

(1) Wood, including paper and various materials made from wood fibre.

(2) Fibrous materials, including the ordinary textiles, hemp, manilla and jute fibres and asbestos.

(3) Stone and clays, including brick, cement, concrete and glass.

(4) Ferrous metals, steel, cast iron, malleable iron, etc.

(5) Copper alloys, brasses, bronzes and other compositions.

(6) Lead, tin, antimony, bearing metals and similar alloys.

(7) Aluminum and other light allows.

Properties of Materials: These materials all have their weak points and their peculiar advantages. A general discussion of properties of materials would embrace the following subjects:

Strength.
Low cost.
Workability or machinability.
Heaviness or lightness.
Toughness
Hardness.
Uniformity of structure.
Resistance to chemical action.
Resistance to high or low temperature.
Resistance to moisture.
Resistance to animal life.
High or low frictional coefficient.
Resistance to abrasion or wear.
Effects resulting from work done upon the material.
Effects resulting from relation of superficial area to volume.

*General Motors Company, Detroit.

Most of these factors have a direct bearing on the strength. Before discussing the effect of these factors, however, let us consider for a moment the definition of strength and the means by which we determine same.

Strength Defined: There are three simple kinds or conditions of strength and three others more complex, as follows:

(a) Tensile strength—resistance to rupture or tearing apart.

(b) Compressive strength—resistance to collapse or crowding together.

(c) Shear strength—resistance of adjacent integral parts to sliding past one another.

(d) Transverse strength—resistance to bending or flexure.

(e) Shock strength—resistance to failure arising from any stress suddenly applied.

(f) Endurance or fatigue strength—resistance to failure from repeated stresses of a value usually less than that of the elastic limit of the material.

Most other conditions of strength can be resolved into the first three. Indeed, it may be safely said that all these are present in any rigid body acted upon by a force. Thus, if a piece of cast iron or hard steel be subjected to compressive stress to the point of failure, it will fly into many pieces as if it were actually pulled apart by powerful tensile stresses. Again, if a piece of soft steel be pulled apart in tension, the rim of the fracture will invariably show the result of shearing action. Likewise, whenever there is shear there are also tensile and compressive stresses.

The methods by means of which these various indications of strength are determined and the manner in which the results are given may be summarized as follows:

Tensile Strength: Obtained by suitable machinery for pulling apart a cylindrical or prismatic test specimen and for weighing the force used in the pulling process. The results are expressed in pounds per square inch of cross section or similar units in the other systems.

There are three other important elements ordinarily brought out in a tensile test, i. e.:

Elastic limit.
Per cent elongation.
Per cent reduction of area.

This elastic limit is expressed in pounds per square inch and is defined as that point on the load-deformation curve, when the numerical ratio of load to deformation ceases to be constant. It is obtained by suitable instruments for measuring the rate of increase in length to increase in load. There is often considerable argument as to the elastic limit of a material because our methods of determining it are only approximate. The more refinement with which we carry out the test, the farther down the stress-strain or load-deformation curve the proportionality appears to cease, while the commercial elastic limit or yield point may be from 2,000 to 15,000 lbs. per square inch, above a reasonably accurate determination of the proportionality limit.

The elongation is variously considered as a measure of the toughness, the hardness and the ductility of the material. As a matter of fact, it is only a very rough approximation of either of these qualities. It does, however, give us some idea of how much energy the material will absorb before failure. If the point of fracture occurs outside the middle third or if the

ratio of gauge length to diameter is different from 4, the elongation thus obtained is not comparable to the elongation of a standard 2" g.l., .505 diameter test specimen.

The per cent reduction of area shows very much the same things that the elongation does, though it is supposed to be a measure of the malleability rather than the ductility. Both the elongation and the reduction of area, with all their limitations, are regarded as the best indications we have on the general reliability of the material.

Compressive Strength: We run into difficulties in making compression tests that are absent in the tensile test. First, if the specimen is long as compared to its cross section, we are apt to get sideways bending instead of true compression. Second, we are running counter to nature in that we are trying to force two particles to occupy space previously occupied by only one. This effect is cumulative as the test progresses.

We can, however, determine the elastic limit in compression and by carrying the tests further we can determine whether the material is brittle or malleable. The test is valuable because there are many materials which will support tremendous loads in compression, but have practically no tensile strength; as, for instance, liquids (in a closed container), stone, brick, concrete and, to a lesser extent, cast iron.

Shear Strength: The shear test is not very often resorted to. First, because of the difficulties and expense of making proper fixtures and of securing a correct value not affected by the bearing values and side thrust forces. Second, because the simpler tensile test gives a reasonably correct means of estimating the shearing strength. A torsion test subjects the material to shearing stress and is sometimes used in place of a shear test. The results of both the shear and compression tests are expressed in pounds per square inch of surface acted upon.

Transverse Strength: The test for transverse strength is quite valuable as it often similates the actual conditions of loading. The transverse test specimen is usually in the form of a beam of uniform section, supported at the ends or cantilever fashion at only one end. The loading is always such as to cause a maximum longitudinal stress at the top and bottom of the beam, with proportional values in between. Whether the stress will be tension at the top and compression on the bottom or vice versa, will depend upon the method of loading. The beam is also subjected to shear both transverse and longitudinal. The failure is almost always caused by the tensile stress, though occasionally a wooden beam will fail in longitudinal shear and a reinforced concrete beam in compression. The results are expressed usually in terms of the tension in the extreme fibres at the elastic limit and at failure. The stress is computed from the formula:

$$\text{Fibre Stress} = \frac{\text{Bending Moment}}{\text{Section Modulus}}$$

The formula holds true only up to the elastic limit of the material, but is used to compute a figure which represents the maximum strength and is called the "Modulus of rupture."

Shock Strength: Which is the antithesis of brittleness, is measured in many ways. There are at least six different machines which are used more or less for this purpose. None of them is quite satisfactory. The stresses caused by these machines are very complex combinations of tension or compression and shear. The velocity of impact is made a fixed quantity when we are certain that different impact velocities have different

effects on materials. The test specimen is usually made with a nick or groove on the tension side, which must needs give complicated stresses incapable of being resolved into simple units. The better way would be to make an impact tensile test on a cylindrical or prismatic test piece, with varying striking velocities and sufficient energy to cause failure on the first blow. Then plot the results thus obtained in foot-pounds of energy per square inch, against velocity of impact.

For other types of material, we may use a transverse impact bending test similar to the Charpy, but without the notch in the bar. Or perhaps we could obtain better results using a drop hammer, increasing the height of fall of the tup by small increments for each blow. The impact strength of brittle materials could be determined in this manner. While the elastic limit or point of permanent set would be the only element obtainable in ductile materials.

Fatigue Strength: The fatigue strength or endurance is fast being recognized as an important quality or property in the construction of machines and articles of every description, the designer never aims to load the material to any point above or even near the elastic limit. But even though the maximum load may be far below the elastic limit, if this stress varies over a considerable range, ultimate failure may result from the repeated stresses. Thus the live axle shaft of a semi-floating automobile axle is subject to a change in stress for every half revolution of the wheel, from a compressive fibre stress of a possible 20,000 pounds per square inch to a tensile stress of a possible 20,000 pounds per square inch, a total variation in stress of 40,000 pounds per square inch twice in a revolution. Failures frequently do occur from this cause.

There are half a dozen machines on the market for determining the fatigue strength, all of them repeating the stress in cycles at a more or less constant speed. The results are expressed in the number of cycles before failure, with a statement as to the stress and the cycle per minute. Another way to do is to determine the stress required to cause failure, in say a million repetitions at various speeds.

Most of the machines used at present for this purpose, test a very restricted section of the specimen, which means erratic results, due to the small volume of metal tested and the stress whorls. The writer is using a machine which gives a constant stress over a test specimen the same size as the standard 2" tensile test piece.

Cost: Returning now to the properties of materials, let us discuss these points and see how they affect the strength or limit its use. In general, the cost depends upon three things, i. e., ratio of amount desired to quantity obtainable, extent of its usefulness, and, third, the work required to get it into the finished shape. We are, however, in this paper, concerned more with the factors bearing directly on the engineering features and cannot dwell on cost analysis here.

Weight: Heaviness is a quality which is desirable only in a comparatively few instances and then only as a means to some other end. For instance, weight is necessary on the drive wheels of a locomotive, automobile or tractor, merely because a portion of this weight is resolved into a force which causes forward motion in the vehicle. Again weight is desired in the rim of a flywheel to cut down the accelerations caused by inequalities in the torque. Again, heaviness is useful in increasing stability of structure when subjected to wind pressure or to vibration from any source.

In general, heaviness is an enemy to the engineer and many times 90%

of the total amount of material he uses merely supports its own weight. Lightness is a thing to be attained by all means and we are justified in spending any amount of money to develop a material which will have at once, the strength of steel and the lightness of wood. (The light automobile in which the material has been utilized to the very best advantage uses two pounds of material for every pound of live load it carries). Not infrequently 30 pounds of material are required to carry one pound of live load.

It is very difficult to arrive at a proper conception of the connection between weight and strength, since the former varies with three dimensions, while the latter varies in general with only two for a given material. The best approximation we can devise is when we assume a constant X-section and express the strength in terms of the third dimension, which is directly proportional to the weight. Imagine a prismatic bar supported at its end and extended to such a depth or height that its weight would be sufficient to cause fracture in the bar. Then

$$\text{Length in ft.} = \frac{\text{Tensile Strength}}{12 \text{ x wt. per cu. in.}}$$

Some examples of this comparison of weight to strength are given below for typical materials. The figures given are average values and indicate the length of a bar set vertically, which will be just sufficient to cause failure. I shall call this figure the strength per unit of weight:

Material.	Length to cause failure by dead weight. Tension.	Compression.
Oak with grain	35,700 feet	20,800 feet
Oak across grain	5,900 "	5,900 "
Yellow pine, with grain	43,500 "	25,400 "
Yellow pine, across grain	2,200 "	5,100 "
Soft wood, with grain	35,700 "	20,800 "
Soft wood, across grain	5,900 "	5,900 "
Manila Rope	20,600 "	...... "
Limestone	35 "	8,818 "
Granite	694 "	17,350 "
1:2:4 Concrete	178 "	3,000 "
Cast Iron	6,400 "	32,000 "
Common Steel	15,000 "	30,000 "
High Grade Alloy Steel	59,000 "	88,000 "
Copper, hard drawn	13,100 "	18,400 "
Aluminum, No. 12 alloy	15,200 "	20,000 "
Duraluminum	28,000 "	40,000 "

From this it is seen that steel is far and away the material having the greatest inherent strength. Wood has excellent inherent strength parallel to the grain, but is woefully lacking in the direction at right angles to it. Aluminum is as strong as common steel, weight for weight, but lacks the ductility and uniformity of the latter.

Workability or Machinability: Next to cost this property is the most important. While its bearing on the strength is quite indirect, it is of such considerable importance that careful consideration should be given. Aside from cost, the greatest advantage of wood over stone or metals is the readiness with which it can be cut and shaped. Likewise the great advantage of concrete is in its adaptability to being poured into shape, as

compared to the slow and tedious methods of working stone, even though the latter has so very much greater strength.

This property of machinability of metals is of vast importance to the manufacturer and user of machines and it is a problem which causes more arguments back and forth between the machinists, engineer and heat treat experts than any other. The writer cannot emphasize too strongly the necessity for our getting straight on this problem, developing standards which will enable us to grade the degree of machinability of every material. It isn't always the hardest steel which is the most difficult to machine either. Frequently the soft, stringy steel gives more trouble than a considerably harder material.

Toughness: In general, toughness is the antithesis of machinability. The steel containing 12% of manganese used for frog points and parts subject to great wear, is quite soft and has relatively mediocre tensile strength, but it is one of the toughest materials known. Alloy steels and manganese bronze have this property to a marked degree.

Hardness: A great deal of work has been done in recent years to establish the degree of hardness of a material and to harmonize this property with that of toughness, machinability and tensile strength. The three best known methods of determining the hardness are the scratch method, using a scale of 10 minerals for roughwork, or for finer work a diamond point requiring a certain pressure to produce a scratch of a certain size; second, the Brinell ball impression method, and finally the sclerescope or bounce method. Owing to the refinement necessary in the scratch method, the latter two methods have gained the greatest prominence. In general the following rules hold for a given material:

(a) Tensile strength increases with hardness to a point where the internal stresses become large, after which it diminishes.

(b) Shock strength decreases with increasing hardness.

(c) Shear and compressive strengths increase with increasing hardness.

Uniformity of Structure: We are badly handicapped in the materials we are compelled to use, in that we have no light material with a uniform structure. All of the readily workable woods, as has already been shown, have a strength in one direction 6 to 20 times that of the other. Our clays and stones are all made up of more or less large heterogeneous particles cemented together rather poorly. It is only in our metals that we approach anything like uniformity of structure and even here we attain only uniformity in a restricted degree. If we could make steel, aluminum or bronze having the solution-like uniformity of glass without its brittleness, we should be at the beginning of a new era in materials.

Resistance to Chemical Action: None of the ordinary materials are strongly resistant to chemical action. The two most common forms of weakness resulting from chemical action are by oxidation or by the dissolving action of acids or alkilis. We find it necessary to form some protective coating of a less active material, as for instance oil, paint, another metal or by a coating of oxide itself, as in the case with aluminum. The action progresses very much more rapidly when there is a combination of the two processes. Thus, where steel is alternately wet by water containing small amounts of acid and then subjected to the action of the oxygen in the air, the destruction is very rapid.

Electrolysis: This is similar in its effect to chemical action. It is not as frequently found destroying materials as chemical action and requires

certain peculiar conditions as an electric current caused by dissimilar metals in a liquid solution, but it occasionally causes considerable trouble. The writer recalls the bottom of a ship made up of a very expensive sheet metal, which was destroyed in a few weeks by the electrolytic action between the monel metal sheet and the steel frames.

Temperature Effects: The effect of high or low temperatures is one of vast importance. For construction purposes we are interested in the strength of materials at temperatures from 40°F below zero to 150°F above zero, but for special purposes we are desirous of using certain materials up to 4,000°F, which is 30 times the range between our winter and summer. None of the materials of vegetable or animal origin can be used in temperatures very much above the boiling point of water, as the water in evaporating breaks down some of the cells and in addition to the valuable resins, saps, tar, etc., which aid in the cohesion of the material, are driven off.

The heavy bearing metals fail almost as quickly as the fibrous materials, though occasionally good up to 600° F.

The ferrous metals have an increase in strength and ductility for several hundred degrees and then have a sharp decrease until at a red heat (1,100° F), it is less than 10% of its strength at ordinary temperatures. At 2,500°F all of our construction metals have reached the liquid condition.

We are limited, therefore, in our explorations of higher temperatures, to the use of a very few refractory oxides and rare metals. It is needless to say at a convention of heat treaters and metallurgists that certain beneficial or detrimental results are obtained in steel and to a lesser extent in other metals, by the manipulation of temperatures.

Another thing to be considered when developing metals, is that low temperatures, even the drop of only a few degrees below freezing of water, increases the brittleness to a surprising extent. Very little has been done in determining the shock strength of various materials at various temperatures. It is a very promising field for research.

Resistance to Moisture: All of the materials having a cellular structure like wood, or a porous structure like most forms of clay and stones, are very seriously weakened by the presence of moisture, though it is more often that a change of the moisture into solid or gaseous phase is the direct cause of the damage. Moisture in cellular materials will cause swelling and distortion of varying degrees, but has no effect on metals except as an aid to chemical action or electrolysis.

Resistance to Animal Life: Here again the materials having a cellular structure are subject to deterioration through bacteria or insects, while metals and inorganic materials are immune from their attacks. The remedy is through the impregnation of the cells with something in the nature of creosote, zinc chloride or an inorganic salt.

Friction Coëfficient: The value of the frictional coëfficient is a very important property when we have rolling or sliding contact between two materials. In some cases we desire a high coefficient as between locomotive wheels and the rails, an automobile drive wheel and the ground, or between brake shoes and the brake drum. More frequently, however, we desire a minimum which is obtained only by means of an oil film. The maintaining of this oil film under all conditions is the greatest problem in securing a bearing of low friction, though the character of the two surfaces is also important.

Usually dissimilar materials operate together better than if the rubbing

surfaces are of the same material. Besides the oil film, attempts are now being made with more or less success to the introduction of a solid lubricating film between two surfaces. The only successful material so far discovered for this purpose is flake graphite.

In the absence of an oil film we are limited in the use of metals for bearing surfaces by reason of the wear or abrasion of one upon the other and second, by the "seizing" or welding action. The wearing action is overcome only by the increasing size of the surfaces, thus decreasing the unit bearing pressure, while the "seizing" action is minimized by the use of a hard service on one side and a soft one on the other. For instance, we have steel on babbitt or bronze; steel or brass on wood or babbitt; hard steel on soft steel, or, better still, cast iron; or the extremely hard jewel surfaces on hard steel.

Effects of Work: The effects of which we are speaking is meant that upon the structure of the material. On wood or natural stone very little can be accomplished. Brick can be made much harder and denser by pressure, but it is only on the metals that the structure can be thoroughly affected by work. Even among the metals we are limited in the extent we can work it—cast iron for instance, cannot be worked. There are two ways in which we can work a metal—hot or cold. The former is usually known as forging or hot rolling and is applied to steel with remarkably beneficial results. The structure is refined and strength and ductility increased to a remarkable degree. Hot working is applied to the copper alloys to a limited extent and very little to other materials.

Cold work can be applied to any of the metals and has a very beneficial effect in making the material more dense, raising the elastic limit (usually at the expense of the ductility, though not always) and to a lesser extent increasing the tensile strength.

Cubes Versus Squares: The effect of the relationship between the superficial area and the volume has been all too little considered. The volume varies with the cube of a given dimension while the area varies as the square. Among the various functions imported to the metallurgist and designer are the following:

(a) Mass or weight is proportional to the *cube* while strength is proportional to the square.

(b) Heat capacity is proportional to the cube while radiating surface is proportional to the square.

(c) Absorption of heat is proportional to the square while capacity is proportional to the cube.

(d) The surface presented for dissolving varies as the square, while the amount to be dissolved varies directly as the cube.

These laws work out in such a manner that if part is made up of a thick or a thin section there is apt to be a wide variation of temperatures between the two sections in either heating or cooling. The result is that two sections attempt to expand or contract at different rates, with disastrous results.

The only way to avoid these internal stresses is to maintain as far as possible, a uniform ratio of superficial area to volume for every section of the particular design.

Conclusion: Just a word in conclusion about the "ideal" material.

First, it must have great strength in all directions in proportion to its weight, which means it must be crystalline or amorphous instead of fibrous or cellular. Second, it must be resistant to heat up to at least 700° F,

which means an inorganic substance and it must become liquid or at least soft under heat, which means it will likely be a metal. Third, it must be workable or machinable at room temperatures. Fourth, it must be plentiful. Finally, it should have a low coefficient of expansion. The nearest guess that the writer can make as to what this "ideal" material will be is that one of the constituents is to be aluminum, magnesium, calcium or lithium held in an alloy or a solid solution by means of an unknown substance.

NOTICE

Change of Headquarters

Beginning November 20th, 1920, address all correspondence to

American Society *for* Steel Treating

4600 Prospect Avenue
CLEVELAND, OHIO

NEW DEPARTMENT AT THE UNIVERSITY OF MICHIGAN

Lieutenant-Colonel A. E. White, President of the American Society for Steel Treating has been promoted from the Department of Chemical Engineering to be Head of the new Department of Engineering Research at Michigan University.

The announcement is as follows:

Aiming to place the University of Michigan in close and intimate contact with the industries of the state so that it may serve them in the most practicable way possible, the Department of Engineering Research has been established and $10,000 appropriated by the Regents for its development.

This department has been inaugurated for the use of the manufacturing concerns of the state to promote investigation and improvement in them, and to aid in all advancement of their welfare. It will be the scientific investigation laboratory for all the industries of the state.

Due to unprecedented industrial development in Michigan this state has risen during the past 10 years from 13th place industrially to 7th place among the states, and its yearly production is many times as great as at that time. The Michigan Agricultural College, devoted largely to the interests of better farming, has been a state institution for a part of the producing organs of the state which produced annually only about $500,000,000 worth of commodities. Up to this time the industries, the producers of wealth evaluated at more than $2,000,000,000 annually, have been left entirely to their own resources, a condition of affairs which will now be reccified by the Department of Engineering Research.

The Regents have appointed Prof. A. E. White of the department of chemical engineering as director of the new department. Professor White has been actively engaged in the bringing about of the laboratory idea and has had wide experience in the line with which the department is to deal. For several years, director of the investigation laboratory of one of the largest manufacturing concerns in the country, he came to the University in 1911 to assume a position as instructor and in 1913 was made assistant professor. Leaving Michigan in 1917, Professor White entered the army with the rank of captain in the Ordnance department, where he had full charge of the metallurgical inspection of all ordnance material.

Rising soon to a major, he left the army in the spring of 1919 with the rank of lieutenant-colonel, when he returned to the University where he was then given the title of full professor. Professor White has recently been elected president of the American Society for Steel Treating, a newly formed organization.

The movement for the installation of a department such as has been effected was started by the Chicago alumni in 1916, but owing to the unsettled conditions of the time, no effective consideration was given the matter until it was brought to the attention of the Regents by the Manufacturers' Association last year. The advisability of establishing the department has been in the hands of a committee consisting of the President, Regents Hanchett, Clements, and Leland. Dean Cooley, and Professors A. E. White and J. C. Emshwiler. This committee has worked with a committee from the Michigan Manufacturers' Association, consisting of M. W. Neal, H. C. Bulkley and F. S. Bigler.

Developing the idea from its inception, these committees have carried it to its present state, and at the last Regents' meeting $10,000 was

appropriated to start the work. Officials regret that more could not be obtained, but present demands upon the University funds are so great that it was found impossible.

Personnel Includes 100 Men

The personnel of the advisory committee appointed to supervise the operations of the department consists of 100 prominent business men about the state, appointed with reference to location and the variety of interests they represent. An executive committee of 17 has been elected by the larger committee and there is also an administrative committee consisting of the dean and heads of professional departments in the engineering college, and the director of the new department.

Speaking of the functions of the new department, Professor White said, "It must be appreciated that this is a state university, and therefore the results of the work done in it must be considered common property. We believe that much valuable work may be done by means of the new department for individual concerns and groups of associations. We do not expect that we will engage in routine work, for that can be done to much better advantage by the various industries.

"It is expected that concerns having work done will pay for the actual cost of the work. The University is very glad to place at the disposal of the manufacturers its library facilities and as much laboratory facilities as can be done without undue interference with teaching. It is believed that this will react most beneficially to the industries and also will aid the University in some small part, as the faculty will thus have an opportunity to keep fully up to date in all problems of industry through the advisory and investigatory work which they will take part in.

"Already, unsolicited, and before the official establishment of the department, many requests for service have come in. They include headlight investigation, requested by prominent motor corporation, research work in the field of a new and cheaper motor fuel, request for help in problems raised by corrosion in the valves and fittings produced by one of the producers in that field, and information on the properties and characteristics of seamless steel belting and many others of similar nature."

The New Standing Committees

At a meeting of the Board of Directors held in Cleveland, October 9th, the following Committees were appointed:

Finance Committee

Mr. W. S. Bidle, Pres., W. S. Bidle Co., Cleveland, Ohio, Chairman, one year.
Mr. J.H. Herron, 2041 E. Third St., Cleveland, Ohio, two years.
Mr. C. M. Campbell, Supt., Pioneer Alloy Products Co., 16601 Euclid Ave., Cleveland, three years.

Publication Committee

Prof. H. M. Boylston, Case School of Applied Science, Cleveland, Ohio, Chairman, one year.
Mr. E. E. Thum, Assoc. Editor, Chemical and Metallurgical Engineering, 10th Ave. at 36th St., N. Y. City, two years.
Mr. J. V. Emmons, Cleveland Twist Drill Co., Cleveland, Ohio, three years.

Meetings and Papers Committee

Mr. H. J. Stagg, Asst. Mgr., Halcomb Steel Co., Syracuse, N. Y., Chairman, one year.

Mr. Geo O. Desautels, Vice Pres., Imperial Drop Forge Co., Indianapolis, Ind., two years.
Mr. Victor Hillman, Metallurgist Compton Knowles, Worcester, Mass., three years.

Library Committee

Mr. J. C. Hartzell, Blue Ash, Ohio, Chairman, one year.
Mr. Z. Jeffries, Aluminum Co. of America, Cleveland, Ohio, three years.

Standards Committee

Mr. T. D. Lynch, Westinghouse Electric and Mfg. Co., Pittsburgh, Pa., Chairman, one year.
Mr. H. L. Green, Willys-Overland Co., Toledo, Ohio, two years.
Mr. P. H. Gilligan, Souther Engineering Co., Hartford, Conn., three years.

Research Committee

Prof. Fred Crabtree, Carnegie Institute of Technology, Pittsburgh, Pa., Chairman, one year.
Mr. H. J. French, Bureau of Standards, Washington, D. C., two years.
Mr. C. N. Dawe, Studebaker Corporation, Detroit, Michigan, three years.

Constitution and By-laws Committee

Capt. C. D. McQuigg, Electro-Metallurgical Co., Niagara Falls, N. Y., Chairman, one year.
Mr. J. E. Halbing, Asst. Supt., Heat Treating, Ingersoll-Rand Co., Phillipsburg, N. J., two years.
Mr. J. C. Morrow, Steel Company of Canada, Hamilton, Ont.

Nominating Committee

Mr. J. F. Harper, Asst. Supt. Forge Shop, Allis-Chalmers Co., Milwaukee, Wis., Chairman, one year.
Mr. H. G. Kiefer, Studebaker Corporation, Detroit, Michigan, one year.
Mr. A. E. Bellis, Springfield Armory, Springfield, Mass., one year.
Mr. A. W. F. Green, Chief of Laboratory, John Illingworth Steel Co., Philadelphia Pa., one year.
Mr. C. U. Scott, care C. U. Scott and Son, Rock Island, Ill., one year.

Membership Committee

Mr. T. E. Barker, 1953 Hastings St., Chicago, Ill., Chairman, one year.
Mr. J. F. Harper, Asst. Supt., Forge Shop, Allis-Chalmers Co., Milwaukee, Wis., two years.
Mr. P. A. Lovegren, Asst. Supt., Standard Forgings Co., Indiana Harbor, Ind., 3 years.

NEW CHAPTER IN SYRACUSE

The first Chapter to be established since the Amalgamation was completed, occurred at Syracuse on the 19th of October. The honor of being the first Chapter was justly deserved by that industrious manufacturing center, as later developments proved.

The preliminary organization meeting was held at the Chamber of Commerce, and was attended by 23 representatives of the leading industries of the city. Here the plans of action were decided upon, and the date of the first meeting determined.

Invitations were sent out to those interested, to meet in the Assembly room of the Chamber of Commerce on Tuesday evening, October 17th. In response to this invitation 175 were present, making necessary the use of an additional room for the meeting and even then many had to stand.

The meeting was addressed by the National Secretary, Mr. W. H. Eisenman and by a number of local men.

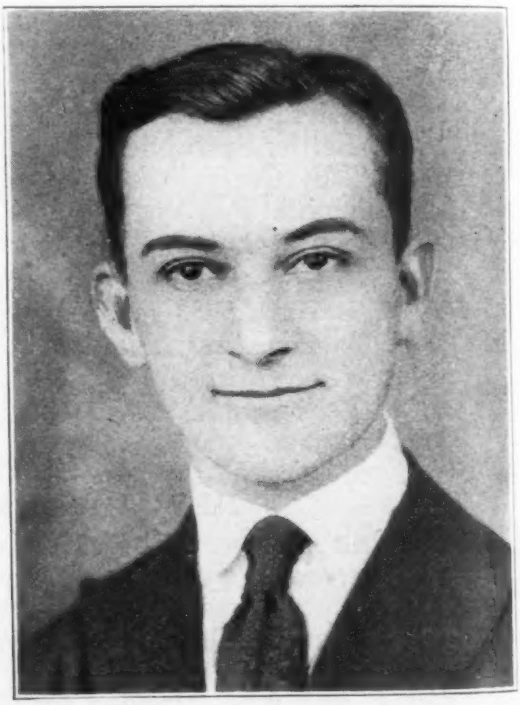
A very lively discussion of points of interest in heat treating was opened up and showed the broad scope and wonderful possibilities of future meetings.

Syracuse, as the Baby Chapter of the Society, established a new record by having 76 applications for membership presented at the opening meeting. The record was formerly held by the Lehigh Valley Chapter with a total of 75 applications.

Syracuse Chapter, with its corp of efficient officers and committeemen, is welcomed by all the other Chapters and the National Board of Directors, with full assurance that the work so auspiciously commenced, will be continued.

The officers selected were as follows: Mr. Howard J. Stagg, Jr., Assistant Manager of the Halcomb Steel Company was elected Chairman; Mr. Frederick C. Raab, Metallurgical Engineer of the Brown-Lipe Chapin, as Vice-Chairman and Mr. William F. McNally, of the Willys Corporation, New Process Gear Division, as Secretary-Treasurer. The following were elected as members of the Executive Committee: Mr. L. M. Fenner, Chief Chemist and Metallurgist, H. H. Franklin Mfg. Co. Mr. R. C. Gebert, Chief Metallurgist, The Hammond Steel Company, Inc. Mr. P. A. Hopkins, Engineer, Penn Spring Works. Mr. E. D. Newkirk, Metallurgist, Onondaga Steel Co., Inc., and Mr. O. L. Van Valkensburg, Chief Chemist, Crucible Steel Company, Sanderson Works.

H. J. STAGG,
Chairman Syracuse Chapter



HARRY BLUMBERG,
Secy.-Treas. Chicago Chapter

CHAPTER NEWS

The Buffalo Chapter of the American Society for Steel Treating held their regular monthly meeting at the University Club on Monday Evening, November 1st. Mr. J. V. Emmons Chief Chemist and Metallurgist of the Cleveland Twist Drill Company gave a very interesting talk on "Tool Hardening Process," which was illustrated with lantern slides.

The Chicago Chapter held their October meeting at the City Club on Tuesday Evening, October 12th. Mr. J. Fletcher Harper, Asst. Supt. Forge Shop of the Allis Chalmers Manufacturing Company and also Chairman of the Milwaukee Chapter, gave an excellent talk on "Deep Etching of Steel." The talk was illustrated by lantern slides.

Mr. T. E. Barker gave a very excellent extemporaneous report of the Convention held in Philadelphia.

* * *

The Tri-City Chapter, under the direction of their Chairman, Mr. Gust Olson, Jr., has inaugurated an intensive campaign to double their membership. Their Membership Committee consisting of ten members, are to choose two men in his own industrial organization or in his vicinity to constitute a team. This membership campaign will be in the form of a contest. The campaign will end at the March meeting.

* * *

The St. Louis Chapter, under the direction of their capable officers, are starting an active campaign for new members.

* * *

As a result of the Philadelphia Convention, which demonstrated the intense interest of the various persons interested in all steel treating, etc., the Philadelphia Chapter has started a campaign to double its membership. The first meeting was held on October 1st and was attended by about 175 people. The second meeting was held on October 25th. The membership Committee reported 52 new members and still going strong.

* * *

The Lehigh Valley Chapter held their regular monthly meeting in the Physics Building of the Lehigh University, October 18th, 1920. Dr. Geo. K. Burgess, Chief Division of Metallurgy, U. S. Bureau of Standards, gave an illustrated talk on "Industrial Research Developments of the Metallurgical Division of the United States Bureau of Standards."

COMMERCIAL ITEMS

Sauveur and Boylston, Metallurgical Engineers, Abbot Building, Harvard Square, Cambridge, Mass., take pleasure in announcing the appointment of their Mr. H. M. Boylston to the Chair of Metallurgy in charge of the Mining Engineering Department, Case School of Applied Science, Cleveland, Ohio, where he will be available for consultation. The firm will continue its laboratories and offices in Cambridge under the supervision of Professor Albert Sauveur.

* * *

Announcement has been made of the appointment of Mr. R. A. Ball, of Pittsburgh, as consulting metallurgist for a number of prominent steel foundries grouped for the purpose of developing and perfecting higher standards in the production of steel castings. Mr. Ball will devote his entire time to preliminary research work immediately and has resigned his position as Vice-President of the Duquesne Steel Foundry Company.

* * *

The Colonial Steel Company has opened a warehouse in the city of Cleveland, renting for that purpose a portion of the building previously occupied by the Betz-Pierce Company. They will carry their own stock of both High Speed and Carbon Tool Steels, and will be represented to the trade by Mr. F. L. Stevenson, Manager, with office at 1104 Prospect Ave., Cleveland, Ohio.

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